120th ASEE Annual Conference & Exposition
FRANKLY, WE DO GIVE A D*MN
June 23-26, 2013

Paper ID #6640

Does a Middle School Intervention for Girls Have Long-Lasting Differential Effects on Their Perceptions of and Participation in Engineering? (research to practice)

Dr. Chrysanthe Demetry, Worcester Polytechnic Institute

Dr. Chrysanthe Demetry is associate professor of Mechanical Engineering and director of the Morgan Teaching & Learning Center at Worcester Polytechnic Institute. Her teaching and scholarship focuses on materials science education, use of educational technology, K-12 engineering outreach, and intercultural learning in experiential education abroad. As director of the Morgan Center at WPI since 2006, Demetry coordinates programs and services fostering excellence and innovation in teaching at WPI and supports course-based and program-level assessment of student learning outcomes.

Ms. Suzanne Sontgerath, Worcester Polytechnic Institute

Sontgerath holds a B.S. in Mechanical Engineering and is currently pursuing an M.Ed. at Worcester State University. She is currently a staff member in the WPI Admissions Office. She is also co-director of WPI's outreach program for middle school girls Camp Reach, and of other high school outreach programs for students.

Does a Middle School Intervention for Girls Have Long-Lasting Differential Effects on Perceptions of Engineering and Engineering Self-Efficacy? (research to practice)

Abstract

This article reports progress in an ongoing longitudinal study of Camp Reach, a two-week residential summer camp at Worcester Polytechnic Institute (WPI) for rising seventh-grade girls that emphasizes the social context of engineering and includes follow-up activities through high school. Participants in Camp Reach are chosen from the applicant pool by random lottery, creating a control group with similar attributes as program participants. Women in both groups are contacted in the years following their high school graduation to explore possible long-term differential effects of the program. The data reported in this article are for program years 2002-2006 (N=124) and focus on the study participants' perceptions of engineering and their engineering self-efficacy, and on the relative impact of various program elements from the viewpoint of alumnae. Results indicate more positive and accurate perceptions of engineering among participants of Camp Reach who sustained their contact with the program and by those in the Control group who later participated in other WPI programs. From the perspectives of study participants, the program elements with the most lasting positive impacts include returning to the program as a staff member, the use of role models, and the teamwork component of Camp Reach.

Introduction

Urgent calls for a larger and more diverse science, technology, engineering, and mathematics (STEM) workforce continue unabated.[1,2] Among numerous recommendations for strengthening K-12 STEM education, the President's Council of Advisors on Science and Technology (PCAST) recently called for a coordinated national initiative to provide experiences outside the classroom to inspire students in STEM.[3] For such experiences aimed at girls, numerous studies suggest that the middle school years are a particularly opportune time for intervention, since girls tend to be shaping their self-image and self-efficacy beliefs related to STEM.[4-11]

Founded in 1997, Camp Reach is a two-week summer engineering enrichment program for rising 7th grade girls, with continuing mentoring, communications, and activities for participants as they advance from seventh grade through their high school years. The program design directly integrates research on factors influencing participation of women in STEM. Formative and summative evaluation, both quantitative and qualitative, have been used since the program's inception for purposes of continuous improvement, and the program has received two national awards for its role in encouraging young women in engineering and as an outstanding model program.

A distinctive element of Camp Reach is its ongoing quasi-experimental study of long-term program effects, enabled by a lottery selection process for the 30 available spots each year. Girls who applied to and attended Camp Reach and girls who applied to Camp Reach but did *not* attend (thus, a Control group) comprise the study sample. Their application to Camp Reach suggests openness to the idea of pursuing STEM educational pathways as sixth graders; however, the lottery selection process allows this characteristic to be spread approximately equally across both groups. Girls in both groups are contacted after their scheduled graduation from high school, and information is gathered about their STEM-related high school experiences, perceptions of engineering, engineering self-efficacy, perceived abilities in STEM areas, and plans for college major.

A longitudinal study of the first five program cohorts (1997-2001) was published in 2009.[12] In the summer of 2012, we made some modifications to the study protocol and contacted the next five program cohorts (2002-2006). In particular, a broader set of questions was used to characterize participants' perceptions of engineering, drawing on a nationally-validated instrument.[13] In addition, we aimed to identify which program elements participants believed to be particularly influential and important. In this paper we begin with a summary of the design of Camp Reach and an overview of previous findings regarding its long-term outcomes. We then describe the methods used in the 2012 study and present a subset of its findings.

Program Design

The program design of Camp Reach attempts to utilize research on effective STEM programming for middle school girls.[8,14] Following are the particular strategies and messages that guide the program design, along with evidence that supports their use:

- An emphasis on engineering as a creative process involving collaborative problem solving;[5,15,16]
- Transparency about the human and social context of engineering and how engineers can make the world a better place;[5,15,17-19]
- A focus on building self-efficacy beliefs and expectations for success in engineering through performance accomplishments and vicarious learning;[20-23]
- Exposure to female role models and mentors in STEM;[1,24-26]
- Opportunities for hands-on design and building activities and use of tools in a single sex environment.[16,27]

The program includes the following major elements and features:

- A real-world service learning project for a local non-profit organization, utilizing the engineering design process and conducted in a team of 10 (3 hours per day);
- Daily hands-on engineering design experiences in a variety of engineering disciplines (3.5 hours per day);
- A spectrum of female role models and mentors in STEM fields, ranging from high school and college women on the program staff, to faculty and practicing engineers;
- A two-week living experience in a college residence hall, with no cell phones allowed and only one phone call home during the program; and
- Sustained contact and additional opportunities in grades 7-12, through project follow-up activities, biannual reunions, newsletters, and the opportunity to be a staff member after completion of their sophomore year of high school.

Previous Research on Camp Reach

In 2009, results from the first five years of the program (1997-2001) were published,[12] representing 176 study participants and a 70% response rate. Four study groups were created in order to capture varying levels of participation in Camp Reach:

1. Camp Reach Partial: Girls who attended the two-week summer program after sixth grade and were sent newsletters through high school, but did not report attending a reunion or other WPI program.
2. Camp Reach Full: Girls who attended the summer program and also sustained their engagement in some way in the years following the program, such as by attending a reunion, participating in another program offered by the same university, or returning as a staff member.
3. Control: Girls who applied to Camp Reach as sixth graders but were not drawn in the lottery to attend and did not attend another STEM-related program in a subsequent year at the same university.
4. Control with WPI: Girls in the Control group who participated in another STEM-related program at WPI as a middle school or high school student.

Following is a summary of findings from the first five years of this longitudinal study; details can be found in Reference 12.

College Entry and Choice of Major

Girls in all study groups were seeking a college education at similarly high levels. Eighteen percent (18.3%) of study participants in the Camp Reach Full group declared engineering majors in college, compared with 2.9% in the Control group. Expanding to include majors in the sciences and science-based professions (e.g., nursing), 46.5% of the Camp Reach Full group was pursuing those pathways, compared to 28.6% of the Control group.

High School Academic Experience

Girls who participated in Camp Reach reported similar STEM-related high school experiences as those who did not, including enrollment in a STEM-enriched public academy, selection of mathematics and science electives, and participation in STEM-related extracurricular activities.

Knowledge of Engineering

One indicator of knowledge of engineering was the number of fields of engineering that study participants could name. Although there were some significant differences between study groups, no differential benefit of participation in Camp Reach was evident by that measure. Participants were also asked to provide a definition of engineering. Those in the Camp Reach Full group were more likely to provide a partial or full definition, but the differences between groups were not statistically significant.

Engineering Self-Efficacy and Self-Confidence

As a measure of engineering self-efficacy, study participants were asked to indicate their level of agreement with the statement "I could be an engineer, if I wanted to." There was a statistically significant difference between the study groups, with the girls who participated in the full Camp Reach intervention or another WPI STEM program rating themselves more highly than the other two groups. Post-hoc comparisons indicated a statistically significant difference between the Camp Reach Full and Camp Reach Partial study groups. A common theme in responses to open-ended questions about Camp Reach was the sense of empowerment and self-confidence created by the program.

As we were planning to extend the longitudinal study to the next five years of program cohorts, we sought to address some gaps and limitations in data collection from the previous study. First and foremost, we looked for better, validated measures of perceptions of engineering and engineering self-efficacy. In addition, we were interested in knowing whether Camp Reach participants could identify some program elements as more important or influential than others. Such information would be helpful in our own efforts to prioritize and refine program elements, and could also be useful to other directors of middle school programs looking to adopt or adapt elements of Camp Reach in their own institutional contexts.

Methods

This study employed a post-only control group design. Girls who attended Camp Reach or applied to Camp Reach in 2002 through 2006 were contacted in the summer of 2012, corresponding to 6 to 10 years after they applied or participated. For those pursuing college degrees, this means that some participants were about to enter college while others had recently graduated from college.

Research Questions

A broad set of research questions was pursued in this study. In this paper, we explore the following subset:

- Does the Camp Reach program have long-term differential effects on the participants' perceptions of engineering?
- Does the Camp Reach program have long-term differential effects on participants' engineering self-efficacy?
- How do participants perceive, in hindsight, the relative long-term impacts of the program's various features?

Sample

Letters were sent by postal mail to 252 women who had applied to Camp Reach in the years 2002 through 2006 when they were in sixth grade: 104 had *not* been selected in the lottery to attend, and 148 had been selected and completed the program. The letter informed them of the purpose of the study, explained that an independent professional would be calling by phone to request an interview, and offered an incentive to participate, which was inclusion in a drawing for two $500 cash prizes. If not connected on the first try, at least three attempts were made to contact each potential study participant. Successful contact was made with 124 women: 82 who attended Camp Reach and 42 who did not (Control). Thus, the response rates within the Camp Reach group and Control group were 55.4% and 40.4%, respectively, with an overall response rate of 49.2%. The primary reason for lack of contact was inactive postal addresses or telephone numbers.

Data Collection

Telephone interviews were conducted by a professional interviewer who had experience interviewing college students and had no affiliation to Camp Reach. The interviewer followed a structured protocol that included both structured and open-ended questions, and she made detailed notes about responses to the open-ended questions. One of the authors coded and entered the data from all interviews. Questions pertained to numerous areas; here we describe only the subset for which results are reported in this paper.

Perceptions of engineering were probed using the "What Do Engineers Do?" questions from the *Core High School 3-6 Month Post-Participation Survey – Engineering Version* disseminated by the Assessing Women and Men in Engineering (AWE) initiative.[13] Various statements about engineers are given, and respondents are asked to rate their level of agreement with each. The AWE Survey uses a 3-level response scale of Agree/Disagree/Don't Know. Anticipating a desire for more nuanced data, we instead used a 5-level response scale: Strongly Agree/Agree/ Neutral/Disagree/Strongly Disagree.

A single indicator of engineering self-efficacy was used: respondents' level of agreement with the statement "I could be an engineer if I wanted to." This question was chosen in order to be consistent with our prior study (i.e., to be able to combine results). The AWE initiative disseminates a much more thorough and validated engineering self-efficacy instrument for this age group, but we decided that we could not incorporate those questions within the time constraints of the interviews.

We were also interested in identifying particularly influential elements of the Camp Reach program, based on the long-term recollections of the participants. Nine specific activities or features were listed, and respondents were asked to rate the degree to which each had a lasting impact, using a 5-level Likert scale.

Analysis

The sample was divided into the four study groups described in the previous section, to be consistent with the earlier years of the study. In order to distinguish between the Camp Reach Partial and Camp Reach Full groups, study participants were asked: 1) if they had participated in any STEM-related programs at WPI in addition to Camp Reach; 2) whether they recalled coming back for a project follow-up activity or reunion in the years following Camp Reach; and 3) whether they had served as a Teaching Assistant (staff member) for Camp Reach. If the answer to any of those three questions was "yes," then the respondent was placed in the Camp Reach Full group. If the answer to all three questions was "no," then the respondent was placed in the Camp Reach Partial group. In order to distinguish between the Control and Control with WPI groups, respondents were asked if they had participated in any WPI programs for older girls after they applied to Camp Reach. If the answer was "yes" or if their names appeared in program records, they were placed in the Control with WPI group.

The SPSS software package was used to generate descriptive statistics and to conduct standard analyses (*t* tests, contingency tables, analysis of variance) for the purpose of determining statistical significance of the findings.

Results

Perceptions of Engineers

As shown in Table 1, all study groups reported reasonably accurate perceptions of engineers. The Camp Reach Full group responded more positively and accurately than the Control group to all five statements probing their perceptions of engineers. Analysis of variance indicated significant differences between groups for three statements. For the statement "*Engineers mainly work with other people to solve problems*," Bonferroni post hoc comparisons indicated that the statistically significant difference was between the Control and Control with WPI groups (p = .04). For the statement "*Engineers work on things that help the world*," the statistically significant difference was between Camp Reach Partial and Control with WPI (p = .03). For *"Engineers mainly work on things that have nothing to do with me,"* post-hoc comparisons indicated significant differences between the Camp Reach Full and Control groups (p = .03) and between Control and Control with WPI (p = .05). In all of these cases, stronger long-term outcomes are associated with additional STEM-related programming following the middle school intervention point, whether through Camp Reach activities or other WPI programs.

Engineering Self-Efficacy

The first five years of the longitudinal study had shown some statistically significant differences between study groups on an indicator of engineering self-efficacy, with girls who participated in the full Camp Reach intervention or another WPI STEM program rating themselves more highly than other girls. Those differences were not evident in the most recent cohorts, as shown in Table 2. While participants in the Camp Reach Full group rated themselves more highly than those in the Camp Reach Partial and Control groups, the differences between groups were not statistically significant.

Relative Impact of Program Elements

As a collective group, alumnae of the Camp Reach program rated 8 of 9 program features as having between "some positive impact" and "lots of positive impact," as shown in Table 3. While these data do not readily identify a subset of program elements as having particular importance, *returning to the program as a Teaching Assistant* (i.e., a counselor) clearly stood out as having the most positive impact. At the other end of the spectrum, participants clearly identified *staying in touch with the Camp Reach community through reunions and newsletters* as the least impactful program element. This result is not surprising given that alumnae

Table 1. Perceptions of Engineers, by Study Group					
	Level of Agreement, Mean and (St Dev)				
Statement	Camp Reach Partial (n=14)	Camp Reach Full (n=68)	Control (n=35)	Control with WPI (n=7)	Total (N=124)
Engineers mainly work on machines and computers.	2.36 (0.75)	2.10 (0.96)	2.49 (0.85)	2.43 (0.98)	2.26 (0.92)
Engineers mainly work with other people to solve problems*	4.14 (0.86)	4.15 (0.61)	3.89 (0.90)	4.71 (0.49)	4.10 (0.74)
Engineers work on things that help the world*	4.21 (0.70)	4.53 (0.59)	4.37 (0.60)	5.00 (0.00)	4.48 (0.60)
Engineers can choose to do many different kinds of jobs	4.64 (0.50)	4.66 (0.48)	4.43 (0.70)	4.86 (0.38)	4.60 (0.55)
Engineers mainly work on things that have nothing to do with me*	1.57 (0.85)	1.34 (0.54)	1.74 (0.85)	1.00 (0.00)	1.46 (0.69)

Note: Rating choices were: 1-*strongly disagree*; 2-*disagree*; 3-*neutral*; 4-*agree*; 5-*strongly agree*.
* $p < 0.05$

Table 2. Mean Ratings of Engineering Self-Efficacy, by Study Group

Study group	*n*	Mean	Standard deviation
Camp Reach partial	14	3.57	1.45
Camp Reach full	68	3.97	1.07
Control	35	3.86	0.94
Control with WPI	7	4.43	0.79

Note: Self-efficacy was measured by level of agreement with the statement "I could be an engineer if I wanted to," on a scale from 1=*strongly disagree* to 5=*strongly agree*.

participation in reunions and newsletters tends to trail off within a few years of the summer experience.

The Camp Reach Full group rated several program elements more positively than the Camp Reach Partial group, but Table 3 shows that only two of those differences attained or approached statistical significance. Not surprisingly, those who had participated in the "full" intervention attached more importance to the program feature designed to help them *stay in touch with the Camp Reach community*, on average giving it a rating of "some positive impact." The Camp

Reach Full group also had more positive recollections of the *community service design project,* which is a major element of the program experience.

Study participants in the Camp Reach Partial group identified *teamwork* as the program element with the most positive lasting impact. Interestingly, their mean rating of teamwork was significantly higher than that of the Camp Reach Full group (Table 3). While we cannot offer an explanation of this result, clearly alumnae look back quite positively on the teamwork experience offered by Camp Reach, regardless of whether they maintained some connection to the program after the summer camp.

Table 3. Impact of Camp Reach Program Elements, by Study Group[a]

	Mean level of impact (st dev)		
Activity or feature	Total *N*=82	Camp Reach partial *n*=14	Camp Reach full *n*=68
Being a Teaching Assistant for Camp Reach[b]	4.89 (0.42)	--	4.89 (0.42)
Teamwork**	4.68 (0.56)	4.93 (0.27)	4.63 (0.60)
Older women TAs and RAs as role models	4.63 (0.64)	4.79 (0.43)	4.60 (0.67)
Community service design project*	4.62 (0.62)	4.36 (0.75)	4.68 (0.58)
Meeting other girls my age with similar interests	4.60 (0.59)	4.43 (0.51)	4.63 (0.60)
Hands-on engineering and science workshops	4.59 (0.61)	4.36 (0.84)	4.63 (0.54)
Being away from home and living in a college dorm for two weeks	4.48 (0.72)	4.43 (0.94)	4.49 (0.68)
Meeting women engineers and scientists in industry	4.46 (0.59)	4.50 (0.52)	4.46 (0.61)
Staying in touch with the Camp Reach community through reunions and newsletters**	3.96 (0.74)	3.36 (0.50)	4.09 (0.73)

[a] Respondents were asked to “Indicate the degree to which each activity or feature of Camp Reach had a lasting impact on you” using a scale of: 1=lots of negative impact; 2=some negative impact; 3=no impact; 4=some positive impact; 5=lots of positive impact

[b] 28 respondents in the Camp Reach Full group reported having been a Teaching Assistant (staff member) in high school.

*$p < 0.10$; **$p < 0.001$

Discussion

The preliminary results reported in this article reinforce and deepen some of the earlier findings and implications of our ongoing longitudinal study. First and foremost, multiple interventions are important; long term outcomes of the program are not as strong for those who participated in only the two-week summer camp after the sixth grade. Moreover, those sixth grade girls who were not selected in the lottery for Camp Reach but later came to another WPI program (Control with WPI group) show strong long-term outcomes. Four of the seven women in this group participated in a one or two week residential program as a high school student, three enrolled in a STEM-enriched public academy in their junior and senior years of high school, and three enrolled as undergraduates at WPI. Thus, other organizations that invest in middle school intervention programs might strengthen their long-term outcomes by facilitating participation in additional STEM programs in the subsequent high school years.

This study also shows that the Camp Reach program design had a statistically significant positive long-term effect on participants' perceptions of engineering. Women in the Camp Reach Full group responded significantly more negatively than those in the Control group to the statement "*Engineers mainly work on things that have nothing to do with me."* The Camp Reach Full group also responded more positively to statements that engineers *"work with other people to solve problems"* and *"work on things that help the world,"* although those differences were not statistically significant. These messages about engineering are emphasized in the program and are aligned with the recommendations of *Changing the Conversation*, the study of public perceptions of engineering by the National Academy of Engineering.[15]

From the perspectives of study participants, the program elements with the most lasting positive impact include returning to the program as a staff member, the use of role models, and the teamwork component of Camp Reach. Many young women are enthusiastic about returning to the program as a "Teaching Assistant" after their sophomore or junior year of high school. They experience the STEM-rich program for a second time, serving as role models for the younger girls and being mentored once again by older staff members with STEM interests. This approach of building in a multiple-intervention experience may be easily adapted by other programs around the country.

The results of this study also emphasize the benefits of utilizing numerous role models in K-12 intervention programs. In the two-week summer program, each cohort of campers is typically introduced directly or indirectly to 9 high school and 6 college women staff with STEM interests, more than 30 program alumnae, 5-10 graduate students and faculty in STEM fields, and more than 20 practicing engineers and scientists. The positive influence of role models on young women with STEM interests is reinforced by numerous studies.[1,24-26,28,29] In our experience, finding volunteers for these types of roles is not difficult or expensive and could be readily implemented or deepened in existing programs of various lengths.

It is more difficult to predict the extent to which the teamwork component of Camp Reach could be adapted broadly by other programs. The service-learning project component of the program is arguably the most challenging to implement. Design project teams work intensively for a two-week period and require skilled facilitation. However, it is possible that study participants were recalling the general absence of a competitive environment or a broader experience of teamwork, such as the collaborative design experiences during the shorter hands-on workshops. Those elements are not difficult to implement.

Analysis of additional data from the 2002-2006 program cohorts is ongoing and will be combined with data from 1997-2001. As such, future publications will include more complete results. Based on findings to date, we offer the following recommendations to other educators who wish to strengthen outcomes of K-12 STEM enrichment programs: infusing programs with volunteer female role models with interests in STEM, creating a pipeline of opportunities and multiple interventions from middle school through high school, and using activities that involve collaboration.

Bibliography

1. Hill, C., Corbett, C., & St. Rose, A. (2010). *Why So Few? Women in Science, Technology, Engineering, and Mathematics.* Washington, D.C.: American Association of University Women.

2. National Academy of Sciences (2010). *Rising above the Gathering Storm, Revisited: Rapidly Approaching Category 5.* Washington, D.C.: National Academies Press. Retrieved from http://www.nap.edu/catalog.php?record_id=12999

3. President's Council of Advisors on Science & Technology (2010). *Prepare and inspire: K-12 education in science, technology, engineering, and math (STEM) for America's future*. Retrieved from http://www.whitehouse.gov/administration/eop/ostp/pcast/docsreports

4. Orenstein, P. (1994). *SchoolGirls: Young Women, Self-Esteem, and the Confidence Gap*. New York: Doubleday.

5. Baker, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32*(1), 3-27.

6. Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching, 32*(3), 243-257.

7. Britner, S. L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of Women and Minorities in Science and Engineering*, *7*(4), 269-283.

8. Clewell, B. C. (2002). Breaking the barriers: the critical middle school years. In *The Jossey-Bass Reader on Gender in Education* (pp. 301-313). San Francisco, CA: Jossey-Bass.

9. Britner, S., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*(5), 485-499.

10. Steinke, J., Lapinski, M.K., Crocker, N., Zietsman-Thomas, A., Williams, Y., Evergreen, S. H., & Kuchibhotla, S. (2007). Assessing media influences on middle school-aged children's perceptions of women in science using the draw-a-scientist test (DAST), *Science Communication*, *29* (1), 35-64.

11. Barton, A.C., Kang, H., Tan, E., O'Neill, T.B., Bautista-Guerra, J., & Brecklin, C. (2012). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal,* published online 23 August 2012, DOI: 10.3102/0002831212458142.

12. Authors (2009). Supporting young women to enter engineering: Long-term effects of a middle school engineering outreach program for girls. *Journal of Women and Minorities in Science and Engineering, 15,* 119-142.

13. Assessing Women and Men in Engineering (n.d.) Retrieved from http://www.engr.psu.edu/awe/

14. Clewell, B. C. (1987). What works and why: Research and theoretical bases of intervention programs in math and science for minority and female middle school students. In A. B. Champagne & L. E. Hornig (Eds.), *Students and Science Learning* (pp. 95-135). Washington, D.C.: American Association for the Advancement of Science.

15. National Academy of Engineering (2008). *Changing the Conversation: Messages for Improving Public Understanding of Engineering.* Washington, D.C.: National Academies Press. Retrieved from http://www.nap.edu/catalog.php?record_id=12187

16. Kahle, J. B. (1996). Opportunities and obstacles: Science education in the schools. In C.-S. Davis, A.B. Ginorio, C.S. Hollenshead, B.B. Lazarus, P.M. Rayman & Associates (Eds.), *The Equity Equation: Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering* (pp. 57-95). San Francisco, CA: Jossey-Bass.

17. Rosser, S.V. (1993). Female friendly science: Including women in curricular content and pedagogy in science. *Journal of General Education, 42*(3), 191-220.

18. Davis, C., & Rosser, S.V. (1996). Program and curricular interventions. In C. Davis, A.B. Ginorio, C.S. Hollenshead, B.B. Lazarus, & P.M. Rayman (Eds.), *The Equity Equation: Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering* (pp. 232-264). San Francisco, CA: Jossey-Bass.

19. Jones, M.G., Howe, A., & Rua, M.J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education, 84*, 180-192.

20. Eccles, J.S. (1994). Understanding women's educational and occupational choices. *Psychology of Women Quarterly, 18* (4), 585-609.

21. Campbell, N. K., & Hackett, G. (1986). The effects of mathematics task performance on math self-efficacy. *Journal of Vocational Behavior, 28*(2), 149-162.

22. Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

23. Betz, N. E. & Hackett, G. (2006). Career self-efficacy theory: Back to the future. *Journal of Career Assessment, 14*(1), 3-11.

24. Hill, O.W., Pettus, W.C., & Hedin, B.A. (1990). Three studies of factors affecting the attitudes of blacks and females toward the pursuit of science and science-related careers. *Journal of Research in Science Teaching, 27*(4), 289-314.

25. Smith, W.S., & Erb, T.O. (1986). Effect of women science career role models on early adolescents' attitudes toward scientists and women in science. *Journal of Research in Science Teaching, 23*(8), 667-676.

26. Evans, M.A., & Whigham, M. (1995). The effect of a role model project upon the attitudes of ninth-grade science students. *Journal of Research in Science Teaching, 32,* 195-204.

27. Stohr-Hunt, P. M. (1996). An analysis of frequency of hands-on experience and science achievement. *Journal of Research in Science Teaching, 33*(1), 101-109.

28. Marx, D. M., & Roman, J. S. (2002). Female role models: Protecting women's math test performance. *Personality and Social Psychology Bulletin, 28,* 1183–1193.

29. Buck, G., Leslie-Pelecky, D., & Kirby, S. (2002). Bringing female scientists into the elementary classroom: Confronting the strength of elementary students' stereotypical images of scientists. *Journal of Elementary Science Education*, *14*(2), 1-9.