The Effectiveness of Single-Gender Engineering Enrichment Programs: A Follow-up Study

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Abstract

Research comparing aspects of single-gender (female-only & male-only) summer enrichment programs to equivalent mixed-gender programs found female-only programs to be effective in educating young girls about engineering, positively influencing their perceptions of engineers and attitudes toward engineering as a career, with mixed results. A recent examination of gains in content knowledge, self-efficacy, beliefs about gender equity and qualitative perceptions of engineers using the Middle School Attitudes toward Engineering, Knowledge of Engineering Careers Survey and the Draw an Engineer Test in equivalent post-4th grade, 2015 summer programs found significantly positive results; females in the single-gender program showed greater improvement in engineering content knowledge than females in a mixed-gender program, as well as significant increases in self-efficacy and perceptions that women can be engineers. A follow-up study was conducted to determine if changes in girls' attitudes towards engineering, perceptions of engineers and gains in content knowledge were sustained. A majority of the students who participated during 2015 returned for the post-5th grade program in 2016 with 50% more new students. Comparisons amongst the 2016 mixed- and single-gender programs and between the 2015 and 2016 programs showed sustained effects for returning students, especially girls, and a greater 2016 impact for girls who participated in the 2015 single-gender program.

Keywords

Single-gender engineering education, Attitudes toward engineering, Draw an Engineer.

Introduction

The need for more professionals entering the science, technology, engineering and mathematics (STEM) fields continues to grow while there are still not enough students pursuing careers in these fields[1-3]. One of the more critical reasons for this is that many students lack an interest in the STEM fields, particularly engineering, primarily due to the absence of engineering topics in K-12 science and mathematics curriculum. Further, the lack of truly integrated STEM instruction[4-7] during their K-12 education leaves students ill-prepared to enter STEM programs in college. Proper academic preparation for college should begin as early as middle school, if not the late elementary grades[8] for students who wish to pursue careers in STEM fields, especially engineering[9]. But, unfortunately due to the lack of engineering topics in elementary and middle school curriculum and a general lack of public knowledge about what engineering is and what engineers actually do[10], too many young students never consider studying engineering because the subject was never introduced to them.

Another critical reason there are so few students pursuing careers in STEM, particularly engineering is the underrepresentation of women[11-14]. Women occupy nearly half the US workforce but less than 25% of the STEM workforce[1, 11, 14]. Research indicates that boys and girls do not differ much in technical abilities or interest in STEM during the elementary and middle school grades, but rather girls develop negative attitudes toward technological studies in the later high school years[15-16]. Research has found that providing young girls with a positive STEM-related experience in middle school, before they develop negative attitudes or lose further interest can have a positive influence on their decision to pursue studies in STEM[17-19].

Science, mathematics and technology classes are not always synthesized and often students are not able to see how classroom lessons relate to real life[20]. Increasing the presence of engineering in K-12 education with practical hands-on applications of science and mathematics as recommended in the *Next Generation Science Standards* (NGSS)[21] should be a priority for educators[22-25]. Unfortunately, high quality curricular materials that integrate science, technology, engineering and mathematics are limited and most teachers are not familia r with engineering and engineering applications and are ill-prepared to present engineering curriculum in their classrooms[26-27]. As a result, many students lack an interest in more advanced studies of science and mathematics and are not academically prepared to enter STEM programs in college - especially engineering.

Background

The Center for Pre-College Programs (CPCP) at New Jersey Institute of Technology (NJIT) offers summer enrichment programs that have been developed to increase high achieving students' interest in the fields of science, technology, engineering and mathematics (STEM). In the absence of quality K-12 STEM curricula in schools, programs of this type can be instrumental in informing young students about careers in STEM, particularly engineering, and help ensure they receive the academic preparation required to enter college programs in STEM. Available middle and elementary school programs span grades four to nine, with each grade level focused on a different field of engineering. The fourth grade program gives students an introduction to environmental engineering, the fifth grade program covers aeronautical engineering, grade six mechanical engineering, seventh grade chemical and civil engineering, eighth grade bio-medical engineering and robotics and ninth grade introduces coding. Students attend classes and participate in hands-on activities designed to introduce students to real-life applications of engineering.

One series of summer programs offered at the Center for Pre-College Programs, Woman in Engineering and Technology, still called FEMME for the original name, "Females in Engineering: Methods, Motivation and Experiences", was designed specifically for young girls in an effort to increase the number of women interested in engineering and other technological careers[28-29]. Middle school is a critical time for students to start thinking about their future and make the appropriate academic choices, but it is particularly important for young girls[30]. Too often, by the time girls reach high school they begin underestimating their own technical abilities and start placing less importance on academic performance, enrolling in fewer mathematics and science courses, and as a result lack the academic background necessary to enter STEM programs in college[31-33].

Summer enrichment programs like FEMME, designed with the goal to increase the number of women interested in STEM careers, especially engineering, in an atmosphere free from male dominance are consistent with recommendations based on the results of prior research on the effectiveness of single-gender education[34-40] (For a review of research on single-gender education and a summary of conclusions see[41]). Results from prior evaluations of the FEMME program found the girls to have significantly more positive attitudes toward STEM, particularly engineering, and significantly more knowledge of engineering careers after attending one of the programs and compared to other students (both male and female) from similar backgrounds[42-45].

The Center for Pre-College Programs also offers mixed-gender and single-gender, male-only programs equivalent to the FEMME programs. Initial evaluations comparing the outcomes and relative effectiveness among the different programs; single-gender (male-only and female-only) and mixed-genders, reported mixed results[41, 46]. Few meaningful differences were found between the males and females within the programs in terms of increased content knowledge or attitudes toward engineering although marked differences were found among the three different gender grouped programs in terms of classroom climate and student interactions in the classroom[46]. And while no differences were found for male students, comparisons between the female students in the female-only programs and the mixed-gender program, did however find meaningful differences in self-efficacy and perceptions of engineers related to issues of gender identity[41].

The programs evaluated during these prior investigations included multiple grade levels and some of the programs included returning students that had previously attended a lower-grade program. As a result those students had some prior knowledge of engineering and may have participated in a program of a different gender composition. Therefore, a more rigorous evaluation was designed to examine gains in content knowledge and look more closely at the issues of self-efficacy, gender equity and qualitative perceptions of engineers using the Middle School Attitudes toward Engineering and Knowledge of Engineering Careers Survey (MATES)[47] and the Draw an Engineer Test (DET)[48] in equivalent post 4th grade female-only, male-only and mixed-gender programs only. Post-fourth grade is lowest grade-level program offered, therefore students would not have attended a previous program at the Center for Pre-College Programs. The results from this study showed gains in content knowledge and positive attitudes towards engineering for all participants, females in the single-gender program showed greater improvement in engineering content knowledge than females in the mixed-gender program, as well as significant increases in self-efficacy and perceptions that women can be engineers. Females in the single-gender program not only developed a perception that they could be an engineer, as a group they developed a more accurate understanding of what engineers actually do. Their drawings of engineers at work collected using the DET were more detailed and more accurate than drawings by students in the other programs[49].

A one-year follow-up study was conducted during the summer of 2016 to determine if changes in the girls' attitudes towards engineering, perceptions of engineers and gains in content knowledge were sustained throughout the subsequent year. Of the 71 students who participated in the three programs during the summer of 2015, approximately 80% (n=54), retuned for the post-5th grade programs in 2016 with 42 new students. With more new students than non-returning students there were four programs offered during 2016; a female-only program, a male-only program and two mixed-gender programs. The current paper is a summary of the preliminary results from the follow-up study, presenting a majority of the results.

Evaluation

The summer began with 25 students in the female-only (FEMME) program, 24 students in the male-only program and in the two mixed-gender programs there were 47 students (24 and 23) for a total of 96 post 5th grade students. Fifty-four were returning students and 42 were new students. Of the 25 girls in the FEMME program 18 had attended the 4th grade FEMME program, 5 had attended the 4th grade mixed-gender program and there were 2 new students. One of the girls who had previously attended the 4th grade FEMME program in 2015 attended one of the mixed-gender programs in 2016. Except for the FEMME programs which had approximately 70% returning students, each of the other programs had approximately 40% returning students. Table 1 is a summary of the ethnic make-up of each program.

Table I
Ethnicity of Students by Program

	------ Program ------		
	Male-only	Female-only	Mixed gender
Caucasian	5	3	5
African American	5	6	15
Hispanic	8	12	21
Asian Indian/Pacific	5	2	6
Bi-racial	1	2	0

As in prior evaluations, students completed; 1) the Middle School Attitudes toward Engineering and Knowledge of Engineering Careers Survey (MATES)[47], 2) separate grade-appropriate content knowledge tests of engineering, mathematics, computer technology and communications, and 3) the Draw an Engineer Test (DET)[48] at the beginning (pre) and the end of the program (post). Due to sporadic absenteeism on the days that the pre and post measures were taken most analyses are based on approximately 23 students per program (N=92 or 93 for most analyses).

Middle School Attitudes to and Knowledge about Engineering Survey

The MATES[47] was developed to measure middle school students' attitudes toward mathematics, science, and especially engineering, and their knowledge about careers in engineering (i.e. what engineers actually do). In addition to students' overall attitudes toward mathematics, science and engineering, six subscales have been identified to measure Interest in engineering: stereotypic aspects (Stereotypic), Interest in engineering: non-stereotypic aspects (Nonstereotypic), Negative opinions (Negative), Positive opinions (Positive), Gender Equity (Gender) and Self-Efficacy for Problem Solving and Technical Skills (i.e. skills needed for engineering).

The MATES also measures knowledge about careers in engineering with a two-part, open-ended question that requires students to "Name five different types of engineers" and to "give an example of the work done by each type". Each type of engineer is coded "1" for correct and "0" for incorrect. Possible total scores range from zero to five. Each example of the work they do is coded “2” for completely correct, “1” for partly correct, and “0” for incorrect. Possible total scores range from zero to ten.

The Draw an Engineer Test

The Draw an Engineer Test was used as a semi-qualitative measure of young students perceptions of who engineers are and what they actually do[48] because previous research has found that purely quantitative measures derived from surveys such as the MATES are not always sufficient to capture cognitive changes in students’ perceptions about engineers[50-51]. Students were asked to draw a picture of an engineer at work and write a short sentence about what the engineer in the picture was doing.

Results

Attitudes toward STEM and Content Knowledge

Three-factor repeated measures analysis of variance techniques were used to test for changes in students’ self-efficacy, attitudes toward engineering and content knowledge as measured by the MATES and program specific content knowledge tests which included mathematics, engineering, computers and communication. Two between subject factors, gender and program (single-gender vs. mixed gender) and one within subject factor (time from beginning to the end of the program) were used to test for differential effects due to gender or/and program. Significant interactions between gender and program are of particular interest as they indicate different outcomes (different changes from pre- to post-) for males and females based on which of the programs they participated in, a single- or mixed-gender program.

Before conducting the above analyses, students’ pre-measures of self-efficacy, attitudes toward engineering and content knowledge were compared based on which of the programs they had attended during 2015 or if they were new students. No significant differences were found indicating that all of the students performed about the same on the pre-test regardless of which program they had attend previously or whether they were a new student.

All students in each of the four programs showed significantly high increases in all areas of content knowledge from the beginning to the end of the programs but there were no significant interactions indicating that gains in content knowledge were consistent across all programs. See Table II for a complete summary.

None of the students in any of the three programs showed significant changes in their overall attitudes towards engineering or in the interest, or positive and negative subscales but significant differences were found in self-efficacy and the gender-equity subscales (see Table II) as was seen the previous summer. Non-significant changes in students’ attitudes from the beginning to the end of enrichment programs such as these are not surprising because students who attend enrichment programs typically start the program with fairly positive attitudes already. But the significant differences in the gender equity and self-efficacy subscales are important. Consistent with previous results, there were almost no changes in the self-efficacy scores for the males in either the mixed or single-gender programs but the self-efficacy scores for the female students in the single-gender program increased significantly while the self-efficacy scores for the female students in the mixed-gender program increased only minimally.

TABLE II

Means and Standard Deviations For Content Knowlegde Tests and MATES Scale(s)

				Beginning	End	F
CONTENT KNOWLEDGE			N	Mean (SD)	Mean (SD)	p
Engineering	Single gender:	Males	24	47.5 (11.7)	68.2 (15.1)	
		Females	24	49.0 (13.3)	83.3 (9.7)	$F_{1.91}$ =1.37
	Mixed gender:	Males	27	54.5 (16.6)	87.0 (13.7)	p=.25
		Females	20	49.2 (14.3)	87.0 (12.8)	
Communications	Single gender:	Males	24	68.0 (3.4)	79.5 (3.7)	
		Females	25	69.7 (3.2)	81.0 (2.6)	$F_{1.92}$ =0.02
	Mixed gender:	Males	27	69.8 (4.5)	85.3 (7.7)	p=.98
		Females	20	69.0 (14.3)	82.0 (8.2)	
Computers	Single gender:	Males	23	80.9 (8.0)	96.7 (3.6)	
		Females	25	83.4 (6.9)	97.2 (4.1)	$F_{1.91}$ =0.24
	Mixed gender:	Males	27	82.2 (7.2)	97.8 (3.1)	p=.62
		Females	20	85.0 (9.6)	96.9 (4.5)	
Mathematics	Single gender:	Males	21	48.9 (18.4)	75.6 (15.9)	
		Females	22	49.2 (11.2)	74.7 (13.5)	$F_{1.86}$ =1.32
	Mixed gender:	Males	27	48.0 (10.0)	68.6 (19.5)	p=.25
		Females	20	45.1 (13.3)	72.8 (16.0)	
MATES						
Overall Attitudes	Single gender:	Males	24	3.7 (0.8)	3.9 (0.7)	
		Females	25	3.9 (0.6)	4.2 (0.7)	$F_{1.92}$ =1.10
	Mixed gender:	Males	27	3.6 (0.6)	3.9 (0.8)	p=.34
Subscales		Females	20	3.6 (0.7)	3.9 (0.8)	
Positive	Single gender:	Males	23	3.2 (1.1)	3.6 (1.0)	
		Females	24	3.6 (0.9)	3.9 (1.1)	$F_{1.90}$ =2.13
	Mixed gender:	Males	27	3.4 (1.1)	3.5 (0.9)	p=.15
		Females	20	3.2 (1.2)	3.4 (0.8)	
Negative*	Single gender:	Males	24	1.9 (0.4)	1.8 (0.6)	
		Females	24	1.6 (0.4)	1.5 (0.6)	$F_{1.91}$ =1.69
	Mixed gender:	Males	27	1.7 (0.5)	1.5 (0.7)	p=.20
		Females	20	1.7 (0.4)	1.5 (0.5)	
Interest	Single gender:	Males	24	2.7 (1.1)	2.8 (1.2)	
Stereotypic		Females	24	2.9 (1.3)	2.9 (1.1)	$F_{1.91}$ =0.98
	Mixed gender:	Males	27	2.8 (1.2)	3.0 (1.3)	p=.42
		Females	20	2.9 (1.1)	2.7 (1.1)	
Non-Stereotypic	Single gender:	Males	24	2.4 (1.2)	2.6 (1.2)	
		Females	24	3.1 (1.1)	3.5 (1.1)	$F_{1.91}$ =0.28
	Mixed gender:	Males	27	2.9 (1.1)	3.3 (1.1)	p=.60
		Females	20	3.1 (1.3)	3.3 (1.3)	
Gender	Single gender:	Males	24	4.6 (1.2)	4.9 (0.9)	
		Females	24	3.9 (1.1)	4.8 (1.1)	$F_{1.91}$ =2.64
	Mixed gender:	Males	27	4.3 (1.1)	4.4 (1.2)	p=.08
		Females	20	4.2 (1.2)	4.8 (1.0)	
Self-Efficacy	Single gender:	Males	24	3.4 (1.0)	3.4 (1.1)	
		Females	24	3.6 (1.1)	4.3 (1.2)	$F_{1.91}$ =2.84
	Mixed gender:	Males	27	4.0 (0.9)	4.1 (1.1)	p=.04
		Females	20	3.4 (1.2)	3.6 (1.0)	

* Subscale items are phrased negatively, so a lower mean is desirable.

Engineers: Their Gender and What They Do?

For purposes of the current follow-up evaluation students' drawings of engineers at work were examined and coded to describe the gender attribution of the engineer and the overall action or meaning of what the engineer was doing. Verbiage in the sentence students provided about what the engineering is doing was examined for the use of key words such as designing, fixing, building, testing, modelling, prototype, drawing blue prints, etc and for the use of "it, he, she, my, or the" to help identify the gender of the engineer. Students often draw a stick figure with no gender or a person with only legs protruding out from under a car or a pair of arms mixing chemicals. When a stick figure, androgynous person or partly hidden person is drawn and described as "it", "my engineer" or "the engineer" in the sentence then the gender of the engineer is coded as unknown. Not all students wrote a sentence and the action and meaning had to be inferred from the drawing as well as the gender when possible. Most drawings were coded as working with hands, holding tools or nothing if the engineer appeared to be just standing there.

The major categories were; 1) Designing or Creating, 2) Building a Model or Prototype, 3) Experimenting or Testing, 4) Helping or Improving, 5) Coding or Programming, 6) Inspecting, 7) Fixing, 8) Making, Building or working with hands, 9) Operating Machines or Crane, 10) Holding tools, 11) Studying or Explaining, and 12) Drawing blue prints. All of the students' pre- and post-drawings were classified into one of these twelve categories and assigned a gender attribution; male, female or unknown.

Students' pre-drawings are summarized in Table III according to which program they attended in 2015 or if they were new students. Most of the drawings produced by the girls who had attended the 4th grade FEMME program showed more accurate portrayals of what engineers do (designing, creating, building a model or a prototype, improving) than for any of the other students which is an indication of the effectiveness of the FEMME program for young girls (most of the students in the mixed-gender program that drew engineers designing, were male).

TABLE III
Summary of What Engineers in Pre-Drawings were doing based on 2015 Program

Engineer was	Single-gender Male	Single-gender Female	Mixed-gender	None\New
Designing\Creating	4	6	5	3
Building Model\Prototype	-	2	1	-
Experiment\Testing	2	2	1	1
Helping\Improving	1	4	-	1
Coding\Programing	1	-	3	2
Inspecting	-	3	1	-
Fixing	4	-	2	11
Making\Building\working	3	3	4	8
Operating Machines\Crane	-	-	-	3
Holding Tools	-	-	-	3
Studying\Explaining	-	1	-	5
Drawing blue prints	-	-	-	2

Based on responses to the open-ended knowledge of careers in engineering question, the girls who attended the 4th grade FEMME program in 2015 were also able to correctly name more types of engineers and give more correct example of the kind of work done by each type, both at the beginning and end of the 5th grade 2016 program.

Table VI is a summary of students pre- and post-drawings for each of the programs during the summer of 2016. Changes in action from fixing, holding tools, building, or operating machines to designing, creating, experimenting, improving or prototyping indicate desirable improvements in students perceptions of what engineers do. Engineers design, solve problems and help make peoples lives better they don't simply fix or build things. For examples, see Figures 1a and 1b below.

TABLE VI
Summary of What Engineers in the Draw an Engineer Test were Doing

	Single-gender				Mixed-gender			
	Male		Female		Male		Female	
Engineer was	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Designing\Creating	5	6	6	10	5	7	2	2
Building Model\Prototype	1	1	2	3	-	-	1	2
Experiment\Testing	1	3	2	2	2	2	3	2
Helping\Improving	1	2	4	2	-	2	2	2
Coding\Programing	2	1	-	1	2	2	2	1
Inspecting	-	-	3	2	1	-	-	2
Fixing	6	3	-	-	7	5	4	4
Making\Building\working	5	4	3	1	6	4	-	3
Operating Machines\Crane	1	1	-	-	1	1	1	-
Holding Tools	-	1	1	-	1	1	2	1
Studying\Explaining	2	1	3	2	1	-	1	-
Drawing blue prints	-	-	1	-	-	-	1	-

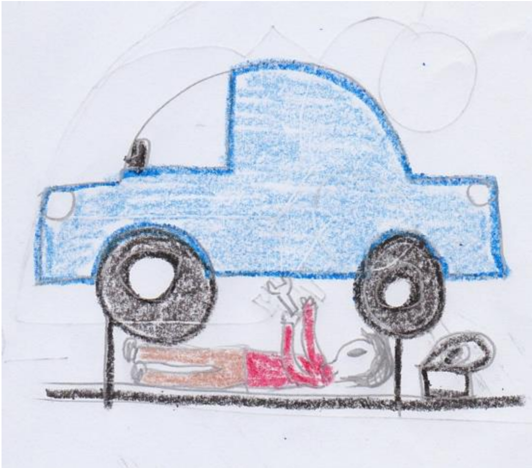

Figure 1a: A new 2016 students indicated the engineer was "fixing a broken car"

Figure 1b: A returning student indicated the engineer was "designing a rocket"

Girls who attended the 4th grade FEMME program during the summer of 2015 showed the most growth in their perceptions of what engineers do. The same is true for the girls who attended the 5th grade FEMME program, with the girls who attended both summers showing more accurate perceptions than students in any of the other programs. None of their pre-drawings showed engineers fixing or just operating machines, they were more likely to draw engineers designing or creating and many of those that did draw engineers who were only building or studying were girls who had not attended the 4th grade FEMME program, although they did draw more accurate post drawings after completing the 5th grade FEMME program.

The males students in the single gender program showed some changes to desiging and creating but also many drew pictures of engineers fixing cars or wires. Many of the males students in the mixed gender program changed their drawings from engineers who were fixing or building but did not describe the engineer as designing or helping as the girls in the FEMME program did.

The gender attributions of students' pre-drawings are summarized in Table V according to which program they attending during 2015. New students who had not attended a program in 2015 are listed as None\New. Of the students who attended the mixed-gender program approximately equal proportions drew male engineers, female engineers or engineers of unknown gender. The same is true for the new students, with slightly more engineers of unknown gender. None of the male students in any of the programs drew a female engineer.

TABLE V
Summary of Gender Attributions in Pre-Drawings based on 2015 Program

	Single-gender Male	Single-gender Female	Mixed-gender	None\New
Engineer was				
Female	-	13	6	10
Male	10	3	8	12
Unknown	5	2	6	17

In contrast, most of the girls who attended the FEMME program in 2015 drew a female engineer in their 2016 pre-drawing. Very few girls in the 2015 mixed-gender program drew a female engineer. These results help support the conclusion that attending the 4th grade FEMME program had a positive and sustained effect on girls' perceptions that females can be engineers (See Figures 2a and 2b for examples of 2016 pre-drawings by girls who attend FEMME4 in 2015).

Figure 2a: Female coding

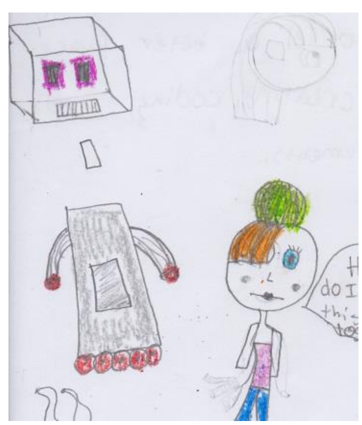

Figure 2a: Female creating robot

Changes in the gender attributions of the engineer from pre-drawing to post-drawing in relation to students' gender and the type of program for the 2016, post 5th grade program; all-male, all female, or mixed-gender; are summarized in Table VI. Again, none of the male students in either the single-gender or mixed gender programs drew female engineers at the end of their program.

TABLE V
Summary of Gender Attributions of Engineers from the Draw an Engineer Test

	Single-gender				Mixed-gender			
	Male		Female		Male		Female	
Engineer's gender	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Male	10	12	3	1	16	20	4	5
Female	0	0	17	20	0	0	12	8
Unknown	14	12	4	3	10	6	3	6

Of the male students in the mixed gender program more than half drew male engineers in their pre- drawings, and even more drew males engineers at the end of the program. Their drawings of the male engineers were more accurate at the end of the program than at the beginning (See Figures 3a and 3b for examples of pre and post drawings).

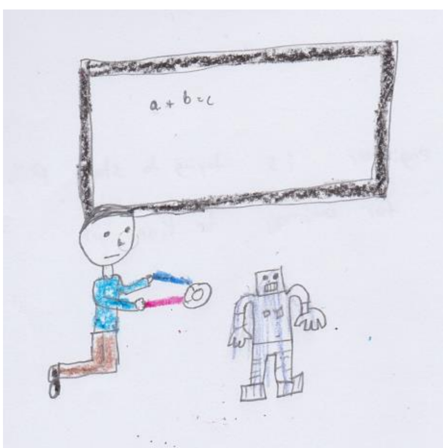

Figure 3a: A male students' male engineer "building a robot" (pre)

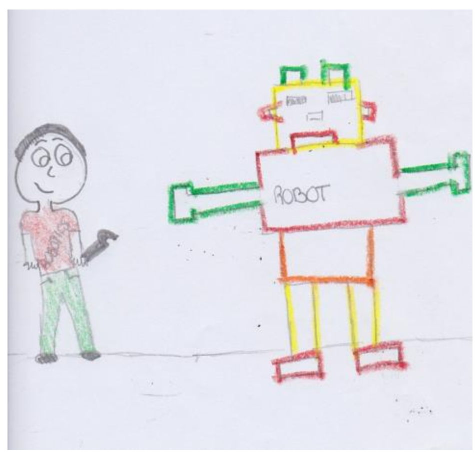

Figure 3b: The same male students' male engineer "designing a robot" (post)

As shown in previously in Figures 2a and 2b, approximalty 75% of the females in the FEMME program drew female engineers at the beginning of the 2016 program and even more drew female engineers at the end of the program.

Of the 19 female students in the mixed gender program more than half drew female engineers at the beginning of the program but much less than half drew female engineers at the end of the progam. Most of the girls who changed the gender of their engineer drew engineers of unknown gender rather than male engineers so it appears that although they were not depicting engineers as male they no longer saw them as female as they did before participating in the program. Further evidence that girls' participation in the FEMME program is important for young girls.

Discussion

Preliminary results of the current follow-up evaluation are extremely positive, indicating that the summer enrichment programs offered by the Center for Pre-College Programs at NJIT are effective in increasing students' knowledge of STEM and STEM careers. While all students, male and female, who participated had positive attitudes toward engineering, the single-gender, female-only FEMME programs seemed to be particularly beneficial for young female students. Female students who participated in the FEMME programs not only learned significant amounts of STEM content knowledge and developed accurate perceptions of what engineers do, they completed the programs with a clear perception that engineers can be females.

Positive effects on female students acquired during the summer of 2015 were sustained through the school year and were still evident from pre-measures for girls who returned during the summer of 2016. The female students in the single-gender program showed greater improvements in engineering content knowledge and computer applications than the female students in the mixed-gender program during the summer of 2015. These results, in addition to significant increases in self-efficacy and an increase in girls' perceptions that women can be engineers, evidenced by the significant increase in the gender equity subscale of the Middle School Attitudes to Engineering Survey (MATES) and changes in gender attribution of engineers in the Draw an Engineer Test, strongly suggests that there are benefits of single-gender programs for female students and that the effectiveness appears long-lasting, not just evident immediately following the end of the program.

Participating in the program appeared to be productive process for the females students in the single-gender program, not only did they develop the perception that they, girls, could be engineers as a group they developed a more accurate understanding of what engineers actually do. The engineers in their drawings were more detailed and more accurate. The engineers were designing and solving problems. Some of the engineers were described as testing a prototype or "helping" make something "better" (improving peoples' lives) which is more consistent with women's preferred career choices, to help improve society.

Further analyses are being conducted to examine correlations among students' responses to subscales on the Middle School Attitudes toward Engineering and Knowledge of Engineering Careers Survey (MATES)[47] (particularly the gender equity subscale), the grade-appropriate content knowledge tests of engineering, mathematics, computer technology and communications, and the Draw an Engineer Test (DET)[48]. Of particular interest are discrepancies between girls' responses to the MATES and characteristics of the engineers in their drawings.

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