SINGLE GENDER PROGRAMS: DO THEY MAKE A DIFFERENCE?

Nicole B. Koppel¹, Rosa M. Cano², Suzanne B. Heyman³ and Howard Kimmel⁴

Abstract - Over the last two decades much work has been done to address the needs of women in science, technology, engineering and mathematics (STEM) areas and to develop interventions that encourage girls to pursue careers in these areas. A popular solution seems to be “single-gender” education but whether or not the positive results of these programs can be attributed to the single-gender environment is questionable. The Center for Pre-college Programs at New Jersey Institute of Technology (NJIT) has offered a “girls-only” Women in Engineering and Technology program (FEMME) since 1981. To test the hypothesis that the positive results of FEMME may be due to good educational methodologies, rather than due to the single-gender environment, NJIT developed the Pre-Engineering Program (PrEP). The PrEP and one of the FEMME programs are identical in every way, except for the inclusion of male students in PrEP. This paper summarizes the current research on single-gender education in STEM and the results of our study.

Index Terms — mechanical engineering, single gender programs, co-educational, attitudes to engineering, women in engineering.

INTRODUCTION

This paper will report on current research about single-gender education in science, technology, engineering and mathematics (STEM) and a comparison study between single-gender versus co-educational classroom environments done at the Center for Pre-college Programs at New Jersey Institute of Technology (NJIT). The rationale for this study evolved from the debate between two schools of thought about whether single-gender education enhances girls’ academic success, especially in STEM areas, or are these positive results due to other reasons, such as small size classrooms, good teachers and teaching methodologies rather than the gender composition of the classroom.

The first section of the paper will discuss the current views on single-gender education programs, the success of this approach, and the reasons behind it. The second section will describe the implementation of the Women in Engineering and Technology (WIET) Initiative-FEMME programs and the Pre-Engineering program (PrEP). The FEMME programs consist of a continuum of five groups of girls completing the fourth through eighth grades while PrEP is geared towards a post-sixth grade co-educational audience. Both programs are designed to improve the science, technology and mathematics backgrounds of academically talented pre-college students while encouraging them to pursue careers in STEM fields. The third section discusses and compares the STEM curriculum, academic results, and student attitudes of the post-sixth grade FEMME group (FEMME6) and PrEP participants.

SINGLE-GENDER EDUCATION – SCHOOLS OF THOUGHT

It is evident that in today’s society “many intelligent women do not achieve similar professional accomplishments as their male counterparts.”[1] The status of women in the workforce shows females still occupy stereotypical roles, such as secretaries, nurses and elementary school teachers.[2] This is in spite of the fact that in the last two decades both girls and boys participation in high school mathematics and science courses has increased and more girls are taking advanced mathematics and science courses in high school. The gender gap in science and mathematics achievement has narrowed significantly and the difference in girls and boys average science and math scores are now minimal. Yet, women are not an equitable segment of the STEM workforce.

Much has been done to address the needs of women and girls in STEM areas. Programs that encourage girls to pursue STEM careers and address their attitudes towards such fields have been developed and established. However, while girls have the ability and the academic background to continue in STEM fields, for a number of individual and societal reasons, young women are not pursuing careers in STEM areas. Only 19% of the science, engineering and technology force is female, a proportion that has changed little in the last 20 years.[3] Research indicates that girls tend to lose interest in science during middle school, fewer girls enroll in elective and advanced high school science and mathematics courses to prepare for college and relatively fewer girls enter undergraduate studies in STEM disciplines, particularly in physical sciences, computer sciences, and engineering. According to a survey completed by all college-bound high school juniors taking the PSAT during academic year 2002-2003, on the national level 16% of male respondents intend on majoring in engineering while only 2% of the female respondents. The limited number of students intending on majoring in engineering is even lower.

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at the state level. In New Jersey, only 12.2% of male respondents intend on majoring in engineering while only 1.6% of the female respondents. [4]

In 1992, the American Association of University Women (AAUW) published “How Schools Shortchanged Girls”, the report that blamed the co-educational system for the academic marginalization of girls which contributed to the under representation of females in STEM areas.[5] This report led members of academia to investigate whether single-gender classrooms counteract girls’ educational deficits. Throughout the country a number of single-gender classrooms and single-gender school environments were developed to test this theory.

The benefit of single gender versus co-educational classroom environment is not clear. On one side of the debate, academicians claim that single-sex schools benefit both male and female students by providing a stronger academic climate and reducing distractions. In particular, in an all female environment, girls will feel comfortable participating in classroom discussions, asking questions without a fear of being judged, and answering questions without fear of erring. Girls will be more easily encouraged to explore a wider range of roles and options. Less tangible benefits from single-gender education include enhanced self-confidence and self-esteem and greater opportunities for leadership roles. Research findings show that in single-sex programs, there is a stronger preference and a heightened regard for math and science among female students as compared to their peers in co-educational programs.[6] In addition, these studies have shown an increase in girls’ risk-taking and gain in their confidence from academic competence.[7] Some studies have shown that single-sex educational programs showed improved academic achievement. In a seven-year study completed by Durost in 1996, the differential between boys and girls in mathematics achievement scores narrowed for girls in single-sex classes.[8] In another study in 1996 by Perry, both boys and girls earned higher grade point averages in single-sex math and science classes than in co-educational settings.[9]

On the other side of the debate, led by a follow-up report released in 1998 by the AAUW entitled, “Separated by Sex: A Critical Look at Single-Sex Education for Girls”, critics claim that there is no evidence that single-gender education is any better than co-educational.[7] The report claims that qualities of a good education, such as good teachers, small class size, a rigorous academic curriculum, parental involvement, behavioral management, and overall high standards, foster student achievement regardless of whether girls and boys learn separately or together. Researchers argue that once single-gender classroom studies were adjusted for socioeconomic or ability variables, the differences in achievement diminished. For example, Harker and Nash confirmed statistically significant differences in academic abilities in favor of girls at single-sex schools until controls were applied for ability level and for social and ethnic backgrounds. Once the controls were taken into accounts, these differences disappeared.[10] Other criticisms of single-gender programs include separating the genders could result in girls seeing themselves as unable to compete in the real world. Single-sex educational environments promote negative stereotypes of the opposite sex and are a set-back to the struggle against “separate but equal” public education.[7]

**STEM Pre-College Programs**

The Center for Pre-College Programs at NJIT has sought to become a driving force in providing increasing access to scientific and technological fields among traditionally underrepresented populations. The Center’s focus has evolved from working with 40 Newark high school students to serving a widening geographical audience of over 4,000 New Jersey students, teachers, parents and educational professionals from kindergarten through twelfth grade.

**A Program for Girls**

In 1981, the Center for Pre-College Programs at NJIT developed and implemented Senior FEMME, the first program within the WIET umbrella, to address the under-representation of women in STEM fields.

Senior FEMME targeted female students completing the 9th grade, as research indicated that girls tend to lose interest in STEM around that age but still could be positively motivated in their choice of STEM high school courses and careers.[11] The summer program provided participants with four-weeks of rigorous academic activities in environmental science, engineering, mathematics, architecture, and computer science.

Senior FEMME was designed to increase the number of women entering and completing scientific careers by providing girls with opportunities to: (1) enhance their mathematics and science achievement while developing their problem solving and critical thinking skills; (2) encourage participants to complete the prerequisite sequence of regular and advanced mathematics and science placement courses in high school; (3) encourage girls to learn about careers in STEM fields and pursue studies where women are traditionally underrepresented; (4) promote girls’ healthy self-esteem and positive self-efficacy, inspiring feelings of competency while challenging their fear of failure; and (5) assess and alter attitudes and beliefs of families towards their female children.

In 1992, Carol Gilligan reported that until age nine girls are cheerful and self-confident. However, by high school, girls have turned inward, become self critical and even self-destructive. Their self-esteem evaporates and they drift towards invisibility.[12] The need for a program to counteract the process that girls seem to undergo after age 9 was apparent to the administrators of the Center for Pre-College Programs at NJIT. Earlier intervention was imperative. Girls should receive science and mathematics enrichment and personal motivation prior to 9th grade. Such
intervention should start at the point when they are still not influenced by “expectations,” academic courses are mandated by school curricula and not minimum requirements, and their sense of self-efficacy is positive.

In 1993, with seed funding from the National Science Foundation (NSF), the WIET umbrella was expanded to encompass post-4th and 5th grade girls (FEMME4 and FEMME5). By 1999, the WIET Initiative—FEMME programs grew to offer 144 high achieving girls from 4th through 8th grade an intensive four-week summer academic program. Girls accepted to FEMME4 in the 4th grade are now able to complete the WIET Initiative at NJIT by attending FEMME programs (FEMME4, FEMME5, FEMME6, FEMME7, and FEMME8) over a period of five consecutive years. A true continuum of single-gender programs was available to girls from 4th through 8th grade.

The structure of the program includes classroom discussions, lectures, laboratory experiments and demonstrations, homework, projects, mentoring sessions and field trips. Each FEMME group has a unique thematic focus such as Environmental, Aeronautical, Mechanical, Chemical, and Biomedical Engineering. Besides hands-on laboratory instruction in the engineering thematic unit, all students receive enrichment in advanced mathematics, communications, and relevant computer programming and applications.

The FEMME programs are not solely designed to enhance girls’ academic skills and to motivate girls to investigate and pursue SMET career options. FEMME programs include curriculum interventions designed to enhance both academic achievement and students’ sense of efficacy.

The goal of increasing the number of women pursuing and successfully completing careers in SMET is part of NJIT’s mission. The most recent long-term follow-up study of 905 FEMME alumni completed in 2002 elicited the following information from 208 respondents who have completed their secondary education and are in graduate-level education or are employed:

### Table I: FEMME Alumni Fields of Study

<table>
<thead>
<tr>
<th>Engineering Fields</th>
<th>Science Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.4%</td>
<td>22.6%</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>Biochemistry</td>
</tr>
<tr>
<td>Ceramic Engineering</td>
<td>Biology</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>Botany</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>Environmental Science</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>Pharmacy</td>
</tr>
<tr>
<td>Engineering (undesignated)</td>
<td>Physics</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>Pre-Med</td>
</tr>
<tr>
<td>Materials Engineering</td>
<td>Science General</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>Technology Fields 3.8%</td>
</tr>
<tr>
<td>Mathematics Fields 10.1%</td>
<td>Computer &amp; Information Science</td>
</tr>
<tr>
<td>Accounting</td>
<td>Non-Technical Fields 36.1%</td>
</tr>
<tr>
<td>Economics and Finance</td>
<td>Undesignated 12.0%</td>
</tr>
<tr>
<td>Mathematics</td>
<td></td>
</tr>
</tbody>
</table>
• Engineering — Students worked in groups to make posters that answered the question “what is a mechanical engineer?”

The students also received instruction in communications, computers, and mathematics and the theme of mechanical engineering was incorporated into each of these components. Field trips, which focused on how mechanical engineering is applied to the “real-world”, enhanced the academic curriculum. Select field trips included the following: Crayola Factory in Easton, PA where the students learned about the engineering processes used in manufacturing markers and crayons; Lehigh University in Bethlehem, PA, where the students got an opportunity to experience a full “college experience” at one of the United States premier engineering universities; Dorney Park in Allentown, PA where the students were able to apply engineering and physics principles learned in class to the amusement park rides; Sony Tech Wonder Museum in New York, NY where the students explored the technology exhibits at the museum including programming a robotic arm to move a ball.

**ACADEMIC COMPARISON – FEMME6 AND PrEP**

FEMME6 and PrEP groups were given a pre and post test that measured their knowledge of mechanical engineering before and after the program. The tests consisted of multiple choice and short answer questions on the information that the students would be introduced to during the four-week summer program. Both the pre and the post exams contained the same concepts but the questions were different. A comparison of the of the two groups’ pre- and post-test analysis can be found below.

**Figure 1: Comparison of Pre and Post-tests PrEP and FEMME6**

As the graph above indicates, FEMME6 students scored slightly higher on the pre test than the PrEP students. This may be attributed to the fact that most FEMME6 students were pre-college alumni therefore they had a foundation of engineering knowledge. Students' average scores in the post tests indicate that all students scored high. The difference between the pre and post test results is statistically significant at the 0.1 level.

**STUDENT ATTITUINAL SURVEY – FEMME6 AND PrEP**

Another tool used to assess student progress is the *Attitudes to Engineering Survey*. During orientation for the summer programs all post 6th through post 8th grade students completed an attitudinal survey. This survey was designed to measure students’ attitudes about engineering, their interest in entering the field and how much students know about engineering. The student represented various socio-economic and race/ethnic backgrounds from whom STEM recruits might be drawn. The survey asked students to rate their opinion on education and careers in STEM. Some questions on the survey included: “Engineers help make peoples’ lives better,” “I think I know what engineers do, “I am good at problems that can be solved in many different ways,” and “I would like to be an engineer when I grow up.”

The students where given the same survey after completing the four-week summer program. The results of the groups’ pre and post surveys showed the following outcomes:

**Table II: Results of Survey**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Don’t know/No opinion</th>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Engineers help make peoples’ lives better.&quot;</td>
<td>PrEP</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>4%</td>
<td>9%</td>
<td>96%</td>
</tr>
<tr>
<td>Post</td>
<td>13%</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>&quot;I think I know what engineers do.&quot;</td>
<td>PrEP</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>21%</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td>Post</td>
<td>25%</td>
<td>14%</td>
<td>5%</td>
</tr>
<tr>
<td>&quot;I am good at problems that can be solved in many different ways.&quot;</td>
<td>PrEP</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>17%</td>
<td>24%</td>
<td>31%</td>
</tr>
<tr>
<td>Post</td>
<td>31%</td>
<td>24%</td>
<td>9%</td>
</tr>
<tr>
<td>&quot;I would like to be an engineer when I grow up.&quot;</td>
<td>PrEP</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>25%</td>
<td>43%</td>
<td>62%</td>
</tr>
<tr>
<td>Post</td>
<td>62%</td>
<td>48%</td>
<td>14%</td>
</tr>
</tbody>
</table>

The current sample of students is not representative of the general population of middle school students in New Jersey; rather they represent students that elected to attend a STEM program. The above results indicate some predictably positive attitudes to STEM education and careers in both the pre and post surveys. The majority of students in both groups felt that “engineers make a difference in peoples lives” even before they attended either FEMME6 or PrEP. Secondly, after attending the summer programs more students felt that they knew what engineers did. Also fewer

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students in both groups felt that they were not good at problems that can be solved in many different ways. The number of students who wanted to be engineers increased for the FEMME group but decreased slightly for the PrEP group. However the percentage of students who were unsure or did not know if they wanted to be engineers when they grew up increased while the percentage of students who did not want to be engineers decreased.

**CONCLUSION**

With the limited number of students being compared in this study, it can be inferred from the results of the pre- and post-tests and the attitudes to engineering survey that there is little to no difference between our single gendered group and our co-educational group. Both groups where successful in improving their knowledge of mechanical engineering concepts and had positive responses to the attitudes to engineering surveys. Our success with both groups may be due to a number of factors. Our classes are small; we have no more than 24 students per group. Our teachers are highly qualified and motivated. Our students are hand selected for their high academic achievements in math and science. Furthermore the students are self-selected in that they choose to apply and attend an academic summer program geared towards STEM careers. We will continue to make more comparisons and collect more data on these two programs.