Abstract - The existing gender disparities in the sciences, especially in the field of engineering, underscore the need for outreach programs to engage young women in such areas. Many programs exist for high school students, but girls may be turned away from engineering at an earlier age. FEMMES (Females Excelling More in Math, Engineering, and Science) is an annual free, one-day event, which provides an exciting, hands-on experience for 4th-6th grade girls from Durham, North Carolina, to encourage them to further explore their potential in these fields. Over 150 participants come to Duke to attend interactive activities designed and led by female faculty. To assess the program’s effectiveness, surveys were completed by participants before and after the event. Each participant assessed her own interest, knowledge, and confidence in math, science, and engineering on a scale of 1 to 10. With respect to engineering, the mean post-event values were significantly higher than pre-event values in all three categories (p < .001). The increase value (± 95% confidence interval) for each category was the following: interest 1.32 (± 0.57); knowledge 1.94 (± 0.58); confidence 1.66 (± 0.63). The increases for engineering were also notably larger than the math and science values, indicating that this type of event especially influences attitudes toward engineering.

Index Terms - active learning, community outreach, gender issues in engineering education, K–12 initiatives and partnerships.

BACKGROUND

Enrichment opportunities are important for K-12 students: it has been recognized that hands-on experiences and exposure to new concepts can have a substantial impact on science learning and motivation. The existing gender disparities in the sciences are well-noted and reveal the need for outreach programs to help engage young women in science, technology, engineering, and mathematics (STEM) fields. Luz Claudio, associate professor at the Mount Sinai School of Medicine, has noted that many young girls are discouraged from pursuing STEM interests because of the stereotypes of STEM subjects and careers as male-oriented and socially undesirable for women [1].

Prior research has shown that exposure to STEM through hands-on experiences and role models can lead to increased self-confidence in scientific ability, increased interest in STEM subjects, improved academic performance, and greater interest in STEM careers. Many intervention programs exist for high school students, but girls may find themselves turned away from science and engineering at a much earlier age. Consequently, students who have the potential to succeed in these fields may be wholly unaware of it. Durham, North Carolina is an under-served community where many students are at socioeconomic disadvantages. Only 23 out of 46 public schools (50%) met expected academic growth standards in the 2006-2007 school year, and only five met high growth standards [2].

PROGRAM DESCRIPTION

For the FEMMES event, over 150 4th-6th grade participants come to Duke for a day to attend an opening keynote speaker, four interactive activities, and a free lunch. Students are placed in small groups (~15), which are led by two female undergraduate and graduate student volunteers, to maximize learning and create a comfortable atmosphere. Activities are designed and led by Duke female faculty members in order to demonstrate that women can and do excel in STEM fields. The activities are held in science and engineering facilities on Duke’s West Campus and last 45 minutes each. Activity subjects are determined by the expertise of the female faculty who lead them and include the following: chemistry, computer programming, genetics, neuroscience, pharmacology, and biomedical, environmental, and mechanical engineering.

DATA COLLECTION AND ANALYSIS

In order to assess the effectiveness of the FEMMES program, surveys were completed by participants before and after the 2007 event (pre and post, respectively). The research protocol was approved by Duke University’s Institutional Review Board (IRB), and parental consent was obtained. Each participant assessed her own interest, knowledge, and confidence in math, science, and engineering on a scale of 1 to 10 (1 = weakest, 10 = strongest). All responses were confidential; thus the data was aggregated, and the difference between the pre and post means was determined. The significance and 95% confidence intervals of the differences were calculated for each category using JMP6.0 software.

RESULTS

The increase in all average values is displayed in Figure 1. Y-bars represent the span of the 95% confidence intervals. With respect to engineering, the mean post-event values were significantly higher than the pre-event values in all three categories, with p-values less than .001.
Post-event values were also significantly higher in all three categories for science, with the most significant change being in interest (p < .001). With respect to math, knowledge and confidence values increased significantly (p < .01 and p < .05, respectively), but values in the category of interest did not change.

DISCUSSION

Our data indicate that the FEMMES event has a positive impact on 4th-6th grade girls’ interest, knowledge, and confidence in engineering. We also observed positive changes in all categories of science and math, except for interest in math. The lack of change for interest in math may be due to the fact that we only hosted one math-centered activity, and the majority of participants did not attend it. The increases for engineering were notably larger than the math and science values, indicating that this type of hands-on event especially influences the girls’ attitudes toward engineering. This could be due to the novel nature of engineering exposure for elementary school students.

The overall positive impact of FEMMES could be attributed to multiple aspects of such an event. For instance, the event was a girls-only opportunity, the activities were interactive, and participants learned in an environment outside of the classroom. To improve upon the surveys of the 2007 event and further pinpoint the most valuable features of the program, the 2008 survey also included questions asking, on a scale of 1 to 10, how important various aspects were to the participant’s positive experience. The continuity of the event’s impact was also not assessed after the 2007 event. However, post-surveys were distributed to participants approximately two months after the 2008 event to evaluate whether the increased interest, knowledge, and confidence is maintained after the event. Lastly, the 2008 surveys were made to allow for a matched-pair analysis, instead of aggregating the data; that is, participants were identified with their surveys by a coded number so we can evaluate the specific participant’s change in values.

In addition to the capstone event, an after-school science club for girls was initiated in January of 2008 at Parkwood Elementary School in Durham, and will be expanded to other facilities in the Fall of 2008. The after-school program consists of a girls’ science club that conducts various hands-on activities led by Duke female students. Further research will investigate the effectiveness of the after-school program along with the capstone event.

Overall, our results indicate that FEMMES leads to meaningful, statistically significant improvements in girls’ attitudes towards STEM fields. Community awareness of FEMMES is constantly increasing, and the number of participants is rising steadily each year; over 200 girls attended the 2008 event. This suggests that FEMMES could serve as a model for other educational outreach efforts, or similar programs at other universities.

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