



Assessing the Impact of Engineering Outreach Frequency on Middle-school Students' Interest in Engineering

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Abstract

Studies have shown that science experience outside of school plays a significant role in influencing students' interest in studying science in the future. Similarly, engineering outreach has been shown to be an effective way to positively affect students' interest in the study of engineering. Additionally, it has been reported that students in middle schools are allowed to make limited choices in their course selection. Thus, the middle-school years appear to be a crucial time in which to engage, expose, and broaden their engineering experience. Therefore, each year for the past nine years, the Engineering Division of the college has hosted National Engineers Week activities for middle school students. During their one and one-half hour visit, the middle school students participate in six engineering demonstrations. The goal of the college in conducting National Engineers Week outreach activities is to expose middle school students to engineering through engineering demonstrations so as to increase their interest in studying engineering in the future. A year ago the authors decided to conduct a study to determine both the immediate and the long-term impact of the Engineers Week activities on the participating students' interest in future engineering study. The results of this study show that the short-term impact of the Engineers Week event demonstrated a significantly higher student interest in considering studying engineering immediately after the event as compared to the pre-event interest. The results also indicated that one year and two years after their participation, students' interest in studying engineering in the future had dropped back down to a level that was significantly lower than the immediate post-visit level but still significantly higher than their pre-visit level. However, these long-term results appear to have been influenced somewhat by the additional exposure to engineering that some students had experienced during the one or two year interval after their initial exposure during the National Engineers Week activities. These initial long-term results indicate that maintaining a high interest in engineering study by middle-school students may be affected by the frequency of exposure to engineering during the middle school period. In this paper, the authors discuss the results of this initial study and their plans for future studies to determine the effect of exposure frequency on the long-term student perception of engineering as a course of study in the future.

Introduction

Engineering outreach programs to middle and high school students are designed to increase students' interest in, and understanding of, engineering so as to inspire them to choose engineering in their future study and career. Before beginning their current study, the authors reviewed the existing literature concerning the influence of these programs on participating students. Many of the outreach programs studied ranged from half-day, one day, a single week or multi-week long summer camp¹⁻¹³. To determine whether early engineering outreach experience has an impact on students' interest in engineering, Bairaktarova, Pilotte, Evangelou & Cox¹ and Salzman, Ricco & Ohland² investigated

what experiences contribute to students' decision in choosing engineering major in college. Their results from surveying incoming freshmen revealed that students learned about engineering through a variety of sources. These include family, middle school and high school classes, teachers, extracurricular activities, summer camp, and university sponsored pre-college engineering activities. Many high school students also had participated in multiple pre-engineering activities. These findings indicate that pre-college engineering activities are part of high school students' life before pursuing engineering in college.

According to the study by Sandrin and Borrer³, many middle and high school students, especially girls, did not know what engineering was in the first place. Therefore, early exposure to what engineering 'is' is the first step in introducing the concept of engineering. The duration and the target audience (middle and/or high school students) of outreach programs vary from institution to institution. Secola, Smiley, Anderson-Rowland, Castro & Tomaszewski⁴ reported that their Saturday Academy, provided to middle school and high school female students in a year-long program, increased their students interest and understanding of engineering substantially. Similar results were described by Yilmaz & Guillen⁵ and Specking & Clausen⁶ after middle and high school students attended summer engineering camp for various durations. Lyons⁷ stated that middle school students' perception of engineering changed significantly (positively) after interacting with engineering students through conversation and project work performed one to two days a week over an entire year. Vernaza & Aggarwal⁸ described a positive impact on the middle school students after their participation in the half-day Mechanical Engineering day event. Students felt they had an increase in engineering knowledge and would recommend their friends who were interested in engineering to participate. Likewise, for students from grades 4-8 who attended the 1-day mechanical engineering outreach also showed an increase in interest in considering engineering as a career as reported by Fleischer, Wemhoff, O'Brien, Ural & LeRoy⁹. Ultimately, Deckard and Quarfoot¹⁰ summed it up in their paper:

“single-day event can be effective in reshaping attitudes, exposing young minds to the world of engineering.”

The above studies demonstrate the short-term effect (immediately after the completion of the outreach program) of engineering outreach to both middle and high school students.

However, very few studies have followed the same group of participants to determine the long-term impact of early outreach program on the students' decision to major in engineering in college. Long-term follow up studies are challenging because of limited resources and the logistics necessary to locate former participants. Nevertheless, Hubelbank, Demetry, Nicholson, Blaisdell, Quinn, Rosenthal & Sontgerath¹¹ conducted a study on the long-term effect of engineering outreach for middle school girls. The 6th graders who participated in a 2-week Camp Reach Engineering program were contacted ten years later and a phone survey was conducted. The results showed that those girls who went back for Camp Reach follow-up activities later on were more likely to choose engineering majors in college. A long-term study by Gooden, Borrego, Edmister, Waller

& Watford¹² yielded similar results. In their study, most of the participants in summer camp had enrolled in college or university. More than half of the students who responded to the survey were major in engineering. The most recent study published by McCormick, Talbert-Hatch & Feldhaus¹³ corroborates the above findings. Their web survey of high school girls who participated in the Power Camp demonstrated a positive correlation between camp participation and the participants' selecting an engineering major in college. It is noted that the time-lap of the long term study relied on the memory of the students who participated in the engineering event. These studies did not report what other types of engineering activities these students had been involved since their initial exposure of engineering outreach, especially during the high school years. According to Hubelbank, Demetry, Nicholson, Blaisdell, Quinn, Rosenthal & Sontgerath¹¹, repeated engineering exposure increased the likelihood of students choosing the engineering field in college.

These long-term studies show that some sort of engineering exposure after the initial engineering outreach increases students' interest in majoring in engineering in college. How frequently do subsequent engineering exposures need to be experienced for middle and high school students to maintain interest in engineering after the initial engineering outreach? In order to answer this question, we first needed to evaluate when student's interest in engineering starts to decline after an initial engineering outreach exposure. Therefore, the authors decided to focus their current initial study on determining the impact of Engineers Week participation on students' longitudinal interest in engineering study by surveying the same group of middle school Engineers Week student participants at one year and two years after the initial exposure. From the results of this initial study, we found that students that had had exposure to additional engineering related events or activities after their Engineers Week exposure showed a greater longitudinal interest in engineering than those students who had not had any additional engineering-related exposure. In this paper the authors will discuss the Engineers Week engineering-related activities, the results of their initial longitudinal study, and the future work they plan to do as a follow-up to this initial study.

Methods

Program design

The Engineers Week activities were conducted by a small public university located in a rural county. The event has been ongoing for the past nine years. Each year, during National Engineers Week, about 230 middle school students from the surrounding area were invited to come to the university to participate in engineering demonstrations. During their one and one-half hour visit, the middle school students, comprised of 6th and 7th graders, participated in six engineering demonstrations. At the beginning of the visit, engineering students from the university conducted a five to ten minute introduction in which they talked to the middle school students about the different types of engineering and what they do, about what students need to study in middle school, high school, and college to become an engineer, and about the engineering demonstrations the participants would see during their visit. After the introduction, the middle school students were split

into 6 groups of 8-12 students each. Led by one or two engineering students, each group of middle school participants was rotated through the six engineering demonstration stations. Each of the three engineering departments (mechanical, civil and environmental, electrical and computing) provided two discipline-specific engineering demonstrations, which were conducted by engineering students and/or engineering faculty. Table 1 presents the type of demonstrations offered by each department, the learning objectives in each, and whether students were allowed to participate in the demonstrations (hands-on/hands-off). The hands-on demonstrations allowed middle school students to operate the instrument and perform the demonstration. The hands-off experiments allowed middle school students to observe only. However, throughout both the hands-on and hands-off demonstrations, the engineering students or engineering faculty discussed the engineering design process and engineering principles related to the demonstration/learning objectives (listed in Table 1) and the expected outcome(s). Each group spent approximately 10 minutes at each of the six demonstration stations.

Table 1: Demonstrations offered during Engineers Week Activities

Demonstrations	Learning Objectives	Department
Hands-on:		
Hovercraft	Design and relate to pressure	Mechanical
Can Crusher	Design and relate to force and simple machine	Mechanical
Robotics	Design of robots	Electrical and Computing
Hands-off:		
Compressive Crush/ Concrete blocks	Forces and structures	Civil and Environmental
Environmental Chemistry/Fluids	Chemical reactions/River and flood plain	Civil and Environmental
Electron-meter	Learn about potential gradient between cloud layer and earth	Electrical and Computing

Example of one demonstration

The can crusher demonstration emphasizes the materials, statics, and solid mechanics concepts of the mechanical design and the engineering principles related to the force generation resulting from the different designs. The demonstration began with middle school students crushed soda cans with three differently-designed can crushers, which were designed and built by mechanical engineering students for the Mechanical Design class. Afterward, the middle school students were asked by the engineering student or faculty demonstrator about which design was the easiest to crush the soda can and which was the hardest. The middle school students were also asked about the design differences between the three can crushers. The engineering student or faculty demonstrator then explained and elaborated on the materials, statics, and solid mechanics concepts of the mechanical design and the engineering principles related to the force generation resulting from the different designs.

Data collection and analysis

The survey questions and survey timeline used in this study are presented in Appendix A. All survey questions were reviewed and approved by the principal of each participating school. Survey data were collected for two groups of students. The first group of students (Group 1) was given a survey regarding an interest in studying engineering before, immediately after, and one year after they had participated in the Engineers Week event. The second group of students (Group 2) was asked to answer a survey regarding engineering interest one year and two years after they participated in the event. Group 2 students were not given a survey before and immediately after their participation in the Engineers Week event. The one- and two-year post participation surveys for both groups included questions about the student's participation in other engineering-related activities after their participation in the Engineers Week event. Tables 2 and 3 show the results of these surveys for Group 1 and Group 2, respectively.

The comparison of the percentage of students interested in engineering before, immediately after, a year after, and two years after participating in the Engineers Week event were analyzed using SPSS 22's Descriptive Statistics, Pearson Chi-Square, and Fisher's Exact Test with $p = 0.05$, two-tail.

Results

Table 2 Group 1: Students interested in studying engineering before, immediately after, and 1 year after participating in the Engineers Week activities.

Response to "Have you thought about studying engineering in the future?"	Yes	No	Maybe/No answer	Total
Before Engr. Week	56 (27.7%)	146 (72.3%)	4	206
Immediately After Engr. Week	150 (71.4%)	60 (28.6%)	14	224
One year after Engr. Week	92 (48.2%)	99 (51.8%)	1	192
Had some engr.-related experience	13 (59.1%)	9 (40.9%)		22
Had no engr.-related experience	79 (46.7%)	90 (53.3%)		169

Results from Table 2 for Group 1 show that only 27.7 % (the number of students in the 'Maybe/No answer' group were eliminated in the total for this calculation) of students were interested in studying engineering before the participation in the Engineers Week event. Although there was a significant increase (71.4%) in interest immediately after the completion of the event, the number of students who were still interested in studying engineering 1 year after the event dropped to 48.2%. However, in the survey responses one year after participation, a difference in the percentage of students interested in studying engineering was noted between those students who had participated in some engineering-related activity during that 1 year (59.1%) and those students who had not participated in an engineering related activity during that time period (46.7%).

Table 3 Group 2: Students interested in studying engineering 1 year and 2 years after participating in the Engineers Week activities.

Response to “Have you thought about studying engineering in the future?”	Yes	No	Maybe/No answer	Total
One year after Engr. Week	56 (35.9%)	100 (64.1%)	1	157
Two years after Engr. Week	21 (39.6%)	32 (60.4%)	0	53
Had some engr.-related Experience	6 (46.2%)	7 (53.8%)		13
Had no engr.-related Experience	15 (37.5%)	25 (62.5%)		40

Results from Table 3 for Group 2 indicate that there is not a statistically significant difference between the percentages of students’ interest in studying engineering at 1 year (35.9%) and at 2 years (39.6%) after attending the Engineers Week event. However, in the survey responses 2 years after participation, a difference in the percentage of students interested in studying engineering was noted as it was in the Group 1 results between those students who had participated in some engineering-related activity during those 2 years (46.2%) and those students who had not participated in an engineering related activity during that time period (37.5%).

Discussion and conclusions

Evaluating the survey results for Group 1, it is not surprising that the participants’ interest in studying engineering significantly increased immediately after the Engineers Week event. This finding agrees with those reported in much of the literature¹⁻¹³. Although, there is a significant drop in student interest in studying engineering one year after participation in the Engineers Week activities, the percentage of students interested in engineering one year after the event was still higher than the percentage found in the initial pre-exposure results. What is the reason for this decrease in interest? Based on the one-year after survey results, 11.5% (22 out of 192) of students said they had participated in some other engineering-related activities during that year. These activities included science events held in another university, drafting and technology classes at the school, and work with parents in home-building projects. However, the middle school students could not recall and, therefore, did not indicate in their survey the specific date they participated in the activities. As noted earlier, the results show a higher percentage of engineering-study interest (59.1%) for these students who had participated in some engineering-related activity during that 1 year than for those students who had not participated in an engineering related activity during that time period (46.7%). This difference may indicate that more frequent exposure to engineering is necessary to sustain interest in engineering over time.

Evaluating the survey results for Group 2 shows that there is no statistical difference between the percent of students interested in studying engineering one year after or two years after participating in the Engineers Week event. However, as noted earlier, in the survey responses 2 years after participation, a difference in the percentage of students

interested in studying engineering was found between those students who had participated in some engineering-related activity during those 2 years (46.2%) and those students who had not participated in an engineering related activity during that time period (37.5%). This difference is similar to that found in Group 1 and perhaps similarly suggests that long-term interest in engineering study can perhaps be maintained by an increased frequency of engineering exposure for middle school students.

The most significant conclusion indicated by the results from this initial study is that middle school students who had exposure to additional engineering-related activities after the initial outreach exposure retain a higher longitudinal interest in engineering compared to those who did not have additional exposure. This result indicates that more frequent engineering outreach throughout middle and high schools may be necessary to have a longitudinal impact on students' interest in studying engineering in college.

Future Studies

As a result of this initial study and due to the sparseness of long-term studies in the literature, the authors plan to conduct studies to determine whether an increase in the frequency of engineering exposure and/or the specific nature of any additional engineering exposure positively affects students' long-term interest in engineering study.

The authors believe that the limited number of schools and students in the small rural area surrounding the university will favorably enable the logistics associated with conducting longitudinal studies of specific student cohorts. In future studies the authors plan to periodically survey the same group of students throughout their remaining middle and high school years, with an emphasis on increasing survey completion percentage, to determine the on-going level of their interest in studying engineering and to determine the specific nature and timing of the other engineering-related activities they have been exposed to during the intervening time. From the results of these studies the authors will attempt to determine any frequency-related effect or the specific type of additional engineering exposure impact students' longitudinal interest in future engineering study. If such effects are found, the authors plan to work with teachers in the local middle schools to develop and implement engineering-related activities to further study exposure frequency and type-of-engineering exposure effects. Since, as noted earlier, the university is located in a small rural area with a limited number of middle school and high school students who later attend college, a partnering institution will be sought out to serve as the basis of comparison for future studies.

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Appendix A: Students survey and timeline

Table 4: Survey timeline

	Pre- and Post- Survey During Initial Engr. Week visit	Post Survey After Engineers Week	
		1 year	2 years
Group 1	2/2014	1/2015	–
Group 2	(2/2013)*	1/2014	1/2015

* No pre- and post-survey conducted

VMI Engineers Week 2014 Pre-Event Survey

Put an X on the appropriate answer

1. Have you heard of VMI Engineers Week before this year?
 - a. Yes _____ Where did you hear it from? _____
 - b. No _____

2. Do you know there are many different types of engineers?
 - a. Yes _____
 - b. No _____

3. Do you personally know any engineer(s)?
 - a. Yes _____
 - b. No _____

4. Have you thought about studying engineering in the future?
 - a. Yes _____
 - b. No _____

5. What is your favorite subject in middle school?

6. Do you like Mathematics?
 - a. Yes _____
 - b. No _____

VMI Engineers Week 2014 Post-Event Survey

Put an X on the appropriate answer.

1. What is your favorite demonstration during your visit? Check all that applied.
 - Crush Concrete
 - Burning of Gummy Bear (Environmental Chem.) or Fluids
 - Hovercraft
 - Can Crusher
 - Robotics
 - Electron-meter

2. Did you participate in any of the demonstration?
 - a. Yes _____ Specify which one(s)? _____
 - b. No _____

3. Do you want to spend more time in any of the demonstration?
 - a. Yes _____ Specify which one(s)? _____
 - b. No _____

4. After seeing all these demonstrations, do you think you will pay more attention to engineering related news and/or event?
 - a. Yes _____
 - b. No _____

5. After seeing all these demonstrations, would you consider studying engineering in the future?
 - a. Yes _____
 - b. No _____

VMI Engineers Week One Year After: Survey

Put an X on the appropriate answer.

1. Did you go to VMI and see demonstrations from the Engineering Division during VMI Engineers Week last year (2014)?
 - a. Yes _____, Continue the survey.
 - b. No _____, STOP.

2. Were you interested in engineering before the visit to VMI during VMI Engineers week?
 - a. Yes _____, Go to question #3
 - b. No _____, Go to question #4

3. After the visit to VMI during VMI Engineers week, did the experience strengthen your interest in engineering?
 - a. Yes _____
 - b. No _____

4. After the visit and in the past year, have you paid more attention to engineering related news and/or events?
 - a. Yes _____
 - b. No _____

5. After the visit and in the past year, have you participated in any engineering related event?
 - a. Yes _____, What did you do and when _____
 - b. No _____

6. After the visit and in the past year, have you considered studying engineering in the future?
 - a. Yes _____
 - b. No _____

VMI Engineers Week Two Year After: Survey

Put an X on the appropriate answer.

1. Did you go to VMI and see demonstrations from the Engineering Division during VMI Engineers Week 2013 (2 years ago)?
 - a. Yes _____, Continue the survey.
 - b. No _____, STOP.

2. After the visit and in the past two years, have you paid more attention to engineering related news and/or events?
 - a. Yes _____
 - b. No _____

3. After the visit and in the past two years, have you participated in any engineering related event?
 - a. Yes _____, What did you do and when _____
 - b. No _____

4. Before coming to VMI Engineers Week, did you think about studying engineering in the future?
 - a. Yes _____
 - b. No _____

5. At present time, do you consider studying engineering in the future?
 - a. Yes _____
 - b. No _____