THE IMPACT OF SCIENTISTS’ AND ENGINEERS’ INVOLVEMENT IN A ONE-DAY PROGRAM FOR MIDDLE SCHOOL STUDENTS AT PRINCETON UNIVERSITY

by

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Shannon Lee Greco (née Swilley)

July 2011
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ABSTRACT

This paper examines the changes in attitudes towards science, scientists and students’ own identities as scientists as a result of their participation in a one-day science and engineering education outreach program. More than 450 middle school students participated in two events held on March 1 and March 4, 2011. The events, called Making Stuff, were each one-day materials science programs conducted by the Princeton Center for Complex Materials education outreach office. PCCM’s education outreach office designed the program to include activity tables, auditorium shows and lab tours all performed by scientists or engineers affiliated with PCCM or Princeton University and its partner organizations. The aim of this paper is to show that a one-day program of direct interaction with research scientists and engineers has a positive impact on students’ attitudes towards science.
INTRODUCTION AND BACKGROUND

The Princeton Center for Complex Materials (PCCM) is a Materials Research Science & Engineering Center funded by a research grant from the National Science Foundation and Princeton University. As part of the multi-million dollar research grant’s conditions, a small portion of the budget is dedicated to satisfying “broader impact” criteria largely understood as education outreach. PCCM’s education outreach office (consisting of myself and the Director of Education Outreach) conducts many different programs to improve science education in the region through the involvement of PCCM’s scientists and engineers, such as the Making Stuff at Princeton events.

Princeton University is located in central New Jersey and less than a 15 minute drive from the city of Trenton, where some of the state’s lowest socio-economic ranked schools are located. The schools served by PCCM span most of the state, with the greatest effort concentrated on Trenton and Asbury Park schools, which are all 95-100% minority students. The percentage of students who are eligible for free or reduced price lunches at the Trenton schools ranges from 60 to 78% of the total student population and 89% for Asbury Park. This is much higher than the state average of 34%. In even sharper contrast, 11% of the students at the public middle school nearest the university are eligible for free or reduced price lunches (“Public School Review,” 2008).

Making Stuff at Princeton was a program designed and conducted by PCCM but it was also part of a larger nation-wide effort to promote materials science. The television series Making Stuff is a four-part materials science NOVA program produced by WGBH/PBS, and supported by the National Science Foundation and the Materials Research Society (MRS). MRS and WGBH/PBS funded efforts of 15 organizations
around the country to bring materials science to the general public, complementing the NOVA series. *Making Stuff at Princeton* was a new series of programs funded, developed, and conducted by PCCM, in partnership and with supplementary support of PBS NOVA. Two of these programs were studied for their effect on student attitudes. These particular events reached more than 300 middle school students from seven schools in New Jersey, including five schools from Trenton. The events included free-choice, open learning environments with activity tables, auditorium shows, and lab tours. While the programs were designed by PCCM Education Outreach staff, the table activities, shows, and tours were conducted by scientists and engineers from Princeton University and partner organizations. These volunteers included scientists and engineers from every point along a researcher’s career path, from undergraduates to full professors and industry professionals.

The events exposed students to these research scientists and engineers as role models and content experts. I conducted this study to determine whether this direct interaction improved students’ attitudes towards science and scientists themselves. The students range widely in their socio-economic background and access to role models in the science, technology, engineering and mathematics (STEM) fields. In the private Catholic school in Princeton, some of the students’ parents are themselves scientists or engineers. Students from Trenton and Asbury Park generally have limited access to actual scientists or engineers (Personal Communication with Anne Marie McCarthey and Maureen Nosal, 2010). The students from Asbury Park attend a charter school that reaches some of the poorest African American children in the state. Most students are the children of Haitian immigrants and speak Creole in the home.
This study sought to answer three primary questions. Does professionally supported interaction between middle school students and research scientists and engineers at the scientists’ and engineers’ institution have a positive impact on:

- Students’ attitudes towards science?
- Students’ attitudes towards scientists?
- Students’ seeing themselves as scientists?

CONCEPTUAL FRAMEWORK

Since the 1960s, American (and European) students have been choosing to take fewer science classes (European Commission, 2004; Rutherford & Ahlgren, 1989). Even in the late 1980s, some were sounding the alarm that America was falling behind in the sciences and that something must be done to improve science literacy (Bybee & Morrow, 1998; Rutherford & Ahlgren, 1989). Unfortunately, things have not improved enough since then (Reid, 2006). The American Association for the Advancement of Science asserts that science literacy is necessary for a country’s citizens to remain economically viable, just and secure in a global society (Rutherford & Ahlgren, 1989).

By now, it is almost common knowledge that the middle school years is an especially critical time when students tend to lose motivation and academic engagement in science (National Research Council and the Institute of Medicine, 2004; Osborne, 2009; Rutherford & Ahlgren, 1989). Not only are students less interested in further study of science after the age of 14, but studies have also shown that it is much more difficult to engage children after that point in their lives (Osbourne, 2009). There is a great need for
programs that positively impact middle school students’ attitudes towards STEM fields. As Reid (2006) and many others stress, negative attitudes toward science may contribute to individuals making choices that can have “potentially very harmful effects at personal, social or national levels” (p. 7).

The Relevance of Science Education (ROSE) project used a Likert-scale survey to compare students’ attitudes towards science in 22 different countries (Jenkins & Nelson, 2005). While slightly older than middle school students, the English subjects of Jenkins and Nelson’s study, as part of the ROSE Project, indicated that they did not like science as much as other subjects. Jenkins and Nelson note also that dislike of science by girls is “particularly marked.” Jenkins and Nelson point out that in all 22 countries participating in the larger ROSE project, science is one of the least popular subjects in school. Much of the data from this study is very disappointing, mostly indicating that school science lessons are failing to capture students’ interest in careers in science, failing to increase curiosity of the natural world, and failing to show “the importance of science for our way of living,” (p. 52).

It is widely recognized that attitudes play a major role in decision-making and adoption of ideas, and this has been getting a lot of attention in the area of science education in the last decade. Reid (2006) notes that negative attitudes towards a subject of study can contribute to the rejection of further study. Efforts to improve attitudes towards science are an important part of science education and are vital to improved science literacy (European Commission, 2004; Fraser, 1981; Osbourne, 2009; Tytler, 2008).
The National Research Council’s Committee on Learning Science in Informal Environments concluded that informal environments can inspire “excitement, interest, and motivation to learn about phenomena in the natural and physical world,” and lead people to “think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science,” (Bell, Shouse, & Feder, 2009, p. 4). The report claims that informal science can complement formal science education, not only to teach science content, but to impact affective and behavioral outcome as well (Bell et al., 2009). Formal science education occurs in schools. Informal science education occurs outside of schools. Informal science education may include television programming, science centers and museums, or even a nature hike. Informal education also includes the education programs of science and engineering research centers such as the Princeton Center for Complex Materials (PCCM).

Scientists and Engineers’ Contribution

The mission of PCCM’s Education Outreach office is to improve science education through the involvement of scientists and engineers. NSF requires recipients of its research awards to contribute to public understanding of science and to help increase the supply of American scientists and engineers (NSF GPG, 2010). There are many who believe this is a reasonable requirement, if not a moral obligation, and that it is greatly needed to boost students’ interest in the sciences. Dusenbery and Morrow (2004) claim that scientists and engineers should participate in science education outreach as they offer “1.) respect and influence in their communities; 2.) deep knowledge of science and the scientific process; 3.) exciting connections to real world exploration and
discovery; 4.) educational access to data and facilities; and 5.) role modeling for students and teachers” (p.1). Additionally, informal exposure to individuals in STEM careers contributes to adolescents’ development of a self-identity that allows them to imagine themselves as scientists (Bolstad & Hipkins, 2008). Tytler et al. (2008) identify this exposure as key to influencing students’ engagement in school science (Figure 1).

Figure 1. Factors influencing engagement with STEM at different stages of schooling (Adapted from Tytler et al., 2008, p. 132, arrows added by author).

The green arrows in the figure above point to areas in which informal precollege science education programs conducted at universities can contribute towards positive
attitudes about science during the middle school years. These factors are those that mention STEM professionals and STEM in practice, both of which students can access via education programs at a research center at a university but are less likely to be found in schools or science museums. A university’s informal science education programs involving scientists and engineers, especially as part of science research grants, can dovetail with school science and parental support to excite students about science. It can also bring awareness to students about the importance of science in our society and to possible careers.

METHODOLOGY

Treatment

The treatment for this study included two one-day events for middle school students held at Princeton University and run by the Princeton Center for Complex Materials (PCCM). Roughly 450 students came to the university to engage in a number of activities with materials scientists and engineers from the university and its partners. The primary venue for each event was a free-choice, open learning environment in which students had the opportunity to interact with science and engineering faculty, technical staff, post-doctoral researchers, graduate students and undergraduates at table activities in a large multi-purpose room on Princeton campus (Figure 2). Each table activity was reviewed and approved, if not provided, by the PCCM Education Outreach staff, consisting of myself and my advisor, the director of PCCM Education Outreach. One-on-one safety and pedagogy training was provided, as well, for the activity presenters. Activities included hands-on explorations of structures that move based on information
from fiber-optic sensors, polymers that change color with electric stimulus, and superconducting materials. Some students made their own polymer “goo” while a polymer engineer explained what makes polymers different from other molecules (Figure 3). Electrical engineers led students in an exploration of energy conversion from solar to electrical to mechanical and then offered an explanation of the physics and chemistry of a solar cell.

*Figures 2 and 3. Students at Making Stuff at Princeton University (March 1, 2011).*

Other components of the event included lab tours such as the cleanroom of the Micro/Nano Fabrication Lab and demonstrations of research equipment such as the scanning electron microscope (SEM) for small groups. Due to limited capacity, not all students attending the *Making Stuff* events participated in the tours and demonstrations.

The treatment also included three auditorium shows on specific materials science topics. Each interactive show lasted 30 minutes and was performed one or two times during the day. One show was on the topic of polymers, presented by polymer scientist and chair of the department of chemical and biological engineering (CBE) Professor Richard Register of PCCM and members of his research group. This show was the result of collaboration between PCCM and LSC and has been tested on numerous audiences.
with much success. The second show, called “The Right Stuff,” was on the topic of “heat, treat or beat” developed and performed by Liberty Science Center exhibit specialist and former materials scientist Harold Clark. PCCM and Princeton CBE graduate student Samantha Saunders assisted Mr. Clark and performed the second showing of “The Right Stuff.” The third show was presented by Professor Rodney Priestley, a young African American polymer scientist and CBE professor, who spoke with the children about his research and his path to becoming a successful researcher. Prof. Priestley, in particular, was chosen as a potential role model for the young minority students in the audience, hopefully dispelling any misconceptions that all scientists are old, white males. The March 1st event included the two polymer scientists’ shows and the March 4th event featured the materials science show. All 450 students attended at least one of the three shows.

The multi-purpose room venue held activity tables and accommodated 250 students at once. Roughly 15 table activities were facilitated by nearly 40 professors and their staff and students, each with buttons to identify themselves as engineers or scientists or both. Some presenters were education professionals who were not scientists and therefore did not wear the buttons. During prep sessions and at the event during setup, each volunteer expert was asked verbally to emphasize important items in their interactions with the students. The items included reminders to tell students they are either a scientist or engineer and something about their personal career path to enhance the chances of students viewing them as role models. We also encouraged volunteers to stress the nature of science with statements like, “How do we know?” and “Let’s find out!” in their interaction with the students.
**Data Collection Methods**

The evaluation of *Making Stuff* was part of an attempt to more rigorously collect data in our programs and further the work we have done in the past in evaluating one-day free-choice learning experiences such as the *Science and Engineering Expo (SEE)* (Steinberg & Greco, 2009). The evaluation of SEE, upon which *Making Stuff*’s evaluation was based, used a survey similar to Fraser’s Test on Science-Related Attitudes (TOSRA) (Fraser, 1981) as a pre- and post-treatment survey. Fraser and his colleagues validated the TOSRA for several countries and age levels, and in particular middle school science students in New York (Wolf & Fraser, 2007). Fraser divided the questions of the survey into 7 distinct dimensions to study cross-correlations to ensure these questions were independent of each other. The survey was shown to be valuable as a snapshot of students’ attitudes or given at intervals for a longitudinal study (Fraser, 1981, Wolf & Fraser, 2007). The survey responses were bolstered by open-ended responses from participants and floor observations. The evaluation of *Making Stuff* for this project was based on the SEE evaluation, but improvements to the methodology were made, including the addition of group interviews and matching of pre- and post-responses.

Surveys, interviews, and floor observations in this study were cross-validated. The three primary data collection instruments were the Modified Test of Science Related Attitudes, the Teacher Focus Group Interview, and the Student Focus Group Interview (Appendices A-C). The survey and student interviews were administered before and after the *Making Stuff*. 
A sample of nine teachers of the students invited to the *Making Stuff* event was interviewed using the Teacher Focus Group Interview three months prior to the treatment to collect their impressions of their students’ attitudes in a group interview (Appendix B). The teachers were asked if they had observed a general disinterest in science among their students and whether this is unique to science or if their colleagues have reported disinterest in other subjects. The teachers were also asked if they introduce students to scientists or engineers, whether in industry or academia. Information was also collected by interview questions on the teachers’ perceptions of their students’ attitudes towards scientists and careers in science, technology, engineering and math (STEM) fields. This data, combined with directly assessing students’ attitudes through a survey and group interviews, provided a baseline for comparison to allow the researcher to measure any gains. Their responses are described in the following section.

Student Focus Group Interviews were conducted with select groups of students both before and after the event (Appendix C). Classes were chosen for interviews from among those in which video-taping was allowed. Video recordings were used to ensure all comments were captured and to fill in details from my note-taking during the interview. The classes selected represented a cross-section of the participants of *Making Stuff at Princeton*: predominantly minority, socio-economically underserved communities in a public school and a private Catholic school in an affluent town. Students were asked about their experiences in science and with scientists. Students were surveyed one month prior to the event with the Modified Test of Science Related Attitudes to collect baseline data (Appendix B). This survey measured general attitudes towards science as a subject of study, as a tool and as a career as well as attitudes towards scientists and engineers.
The survey asked students to rate their agreement with statements on a Likert-scale. Surveys were delivered to teachers for distribution among their students to complete in class. Responses were kept anonymous by assigning each respondent a unique identifier linked to their name and school on a tear-off sheet. The tear off sheets and names were only used to link identifiers to analyze the pre- and post-data and were kept separate from the responses throughout analysis. The unique identifiers of students was one of the improvements made to the evaluation plan for our programs, enabling us to anonymously match pre-and post-responses rather than seeing a change in the mean before and after treatment.

Following the event, students were given the Modified Test of Science Related Attitudes as a post-survey with the same Likert-scale questions to measure any gains in attitudes towards science, scientists, and seeing themselves as scientists. The only difference between the questions was the last two on the survey. In the pre-survey, the Modified Test of Science Related Attitudes asked the students “Have you ever met a scientist?” and “Have you ever met an engineer?” In the post-survey, the survey asked the students “How many scientists have you met?” and “How many engineers have you met?” This data was matched and compared to the pre-event survey responses in a matched paired t-test resulting in a sample size of 160 students who answered both the pre- and the post-treatment Modified Test of Science Related Attitudes. Students also participated in Student Focus Group Interviews after the treatment in which the same questions were asked of them as in the pre-event interviews. New questions specific to their experience at the event were also added. Students were asked in the post-event
interviews about the scientists and engineers they met. Students were also asked about gains in attitudes towards science.

Data from the survey, student interviews, and teacher interviews were triangulated to give a more complete picture of the students’ attitudes and the changes as a result of the treatment. The data from the student interviews, teacher interviews and surveys were compared to find patterns of support or inconsistencies across the three methods of data collection. Questions from the survey were combined into categories, those that relate to attitudes towards science, attitudes towards scientists, and career/self-as-scientist to look for gains in these areas. Additionally, students’ responses were compared by school, gender, and race/ethnicity to look for similarities or disparities.

Most of the Modified Test of Science Related Attitudes questions come from Fraser’s Test of Science Related Attitudes (TOSRA). Because the author cannot expect to influence students’ attitudes towards school science lessons with a treatment that occurs outside of school, questions related to school science lessons were eliminated from Fraser’s TOSRA to create the survey for this study. Added questions included paraphrased survey questions from large scale surveys of students in New Zealand conducted by the National Education Monitory Programme (NEMP) (Crooks & Flockton, 1996, 2000, 2004, cited in Bolstad & Hipkins, 2008). These are instruments that have reliably measured students’ attitudes towards science in Australia, New Zealand, the United States, and other countries (Wolf & Fraser, 2007). Questions added by the author were reviewed by experts in the field, such as Steinberg and Wilkerson, and are considered to be valid, but will be further validated upon review of this paper. Likewise, I have validated the interview questions in pilot studies and they have been
reviewed by Steinberg. The research methodology for this project received an exemption by Princeton University’s and Montana State University’s Institutional Review Board and compliance for working with human subjects was maintained.

DATA AND ANALYSIS

The results of the Teacher Focus Group Interview revealed 100% of the teachers interviewed felt their students’ attitudes toward science were positive ($N=9$) (Appendix B). This was supported by the students’ responses in both the surveys and Student Focus Group Interviews (Appendix C). The mean of students’ responses to the statement *I like science*, was 4.094 before the treatment (on a scale from one to five, five being “strongly agree”) and 4.125 after the treatment, a statistically increase from an already high rating (change=0.031, $P=0.5892$, $N=160$). In the pretreatment Student Focus Group Interviews, 94% of Group A (100% minority, 27.8% female, $n=18$) reported that they liked science and 27.8% said it was their favorite subject. Group B (100% non-minority, 50% female, $n=16$) reported that they all liked science and 18.75% felt it was their favorites subject. However, Group A’s school appeared more neutral in the pre-treatment Modified Test of Science Related Attitudes survey than in the interview. The mean score on the survey was of 3.31 for the statement “I like science,” a score of 3 corresponding to the choice “not sure” on the Likert scale and a mean of 3.625 post-treatment.

Teachers’ perceived student misconceptions about the nature of science fell into three categories: social, process/nature of science, and content. In the social area, misconceptions about science mixed with those about scientists. Teachers felt their students often think science is boring, “geeky,” and lonely, even thinking they “had no
families.” A few mentioned the “mad scientist.” The loneliness aspect was further explained as an impression that science work is not collaborative. Several teachers suggested their students might perceive science to be “stagnant,” with “one answer that lasts forever.” Similarly, according to the teachers, students might feel there is only one way to approach a problem or experiment.

Teachers also offered possible misconceptions about scientists when prompted. These included students’ impressions that all scientists are geeky, nerds, old, white, and male. Most agreed that geeky and nerd were common terms students would use to describe scientists (Table 1). One third of the teachers interviewed agreed that their students think scientists are old, one even suggesting that some students might think “all scientists died a hundred years ago.” The question about misconceptions about scientists prompted one teacher to say that his students think scientists are geniuses and that the students feel they are “not smart enough to be a scientist.” Four of nine teachers expressed their concern about a general lack of confidence among students in this way. A teacher from a predominantly minority school low in the state’s ranking of districts for socio-economic factors spoke of a student who attended another program of PCCM’s similar to the treatment in this study. She said that, when asked his impression of the program, he replied, “I felt like maybe I could be smart someday also.”
Table 1  
*Common Misconceptions Reported by Middle School Teachers (N=9)*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Misconception (category)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientists</td>
<td>Geeky/nerds (social)</td>
</tr>
<tr>
<td></td>
<td>Lonely, no family (social)</td>
</tr>
<tr>
<td></td>
<td>Old (social)</td>
</tr>
<tr>
<td></td>
<td>White (social)</td>
</tr>
<tr>
<td></td>
<td>Male (social)</td>
</tr>
<tr>
<td></td>
<td>“Mad scientist” (social)</td>
</tr>
<tr>
<td></td>
<td>Genius (content)</td>
</tr>
<tr>
<td></td>
<td>Dead</td>
</tr>
<tr>
<td>Science</td>
<td>Stagnant, unchanging (process)</td>
</tr>
<tr>
<td></td>
<td>One answer, one approach (process)</td>
</tr>
<tr>
<td></td>
<td>Not collaborative (process)</td>
</tr>
<tr>
<td></td>
<td>Models are exact representations, one is “right” (content/process)</td>
</tr>
</tbody>
</table>

The teachers’ opinions about their students’ misconceptions about scientists were not supported in the Student Focus Group Interviews. In both the pre- and post-interviews, students in both Group A and B described scientists as those who *figure things out* and *come up with new things*. Group A used the words *curious, outgoing, and helpful* in the pre-treatment Student Focus Group Interview. When asked what science is, Group A’s answers revolved around either *exploring* (two students mentioned this) and *cooking* (three students mentioned this). Only one male student in Group A mentioned a scientist who was no longer living. In support of students’ positive attitudes towards science, the larger sample of students who took the Modified Test of Science Related Attitudes agreed with the following statements before the treatment (mean scores in parentheses, one being *strongly disagree* and five being *strongly agree*): *I enjoy meeting real scientists* (3.796); *Scientists and engineers try to discover truth about natural and man-made things* (3.949); and *If you met a scientist, he/she would probably*
look like anyone else you might meet (3.901). Students disagreed with the negatively worded statement, *Scientists are less friendly than other people* (2.051). Students also agreed with the statement, *Women are as good as men at science* (4.282) ($N=160$).

A little less than half of the teachers in the Teacher Focus Group Interview reported that they had introduced their students to scientists (four out of nine). During the Student Focus Group Interviews prior to the treatment, Group A reported that 38.9% had met a scientist and 16.7% said they had met an engineer ($n=18$). In Group B, 87.5% said they had met a scientist and 100% had met engineers ($n=16$). For the entire sample of those who took the Modified Test of Science Related Attitudes before the treatment, 56.4% said they had met a scientist and 61.3% had met an engineer ($N=204$). The teachers who reported that their students have met scientists said it is a positive thing.

The teachers asked acknowledged that scientists with experience would have a more positive impact. (PCCM provides such experience to scientists.) The value of meeting scientists, according to the teachers, was exposure to careers in science and the impact of those careers, as well as understanding the nature of science. In student pre-interviews, Group A, a small charter school in a poor area without many resources, was not very sure whether they had met scientists or not. Eleven percent of the students reported that a scientist had come to their previous school, and one mentioned Alfred Wegener and his theory of Plate Tectonics before the question was clarified for him that scientists he had met in person were of interest ($N=18$). When asked about engineers, only one reported that his own mother had been an engineer. Two others in the class mentioned that they had met engineers, but upon further probing, it became clear that they considered car mechanics to be engineers. For Group A’s school overall, 22.2% reported in the
Modified Test of Science Related Attitudes that they had met a scientist before the
treatment and 27.8% reported they had met an engineer in the survey responses \( (n=16) \). Group B, a private Catholic school across the street from Princeton University, had
nearly all met scientists or engineers; 87.5% reported that they had met at least one
scientist and 100% reported that they had met an engineer \( (n=16) \). Many of these students further explained that the scientist or engineer was a parent or a friend’s parent.
Group B’s school survey results indicated that 61.9% had met a scientist and 74.6% had
met an engineer \( (n=63) \).

In the post-treatment Student Focus Group Interviews, Group B \( (n=15) \) had more
obviously negative comments about scientists than Group A \( (n=22) \) (three negative statements in Group B vs. one in Group A). The higher number of negative comments came from the group that had more experience with scientists having met more scientists before the treatment. After the treatment, Group B’s negative comments describing scientists included phrases such as *know-it-all, off topic, awkward,* and *should have been more prepared.* Group B also had a few neutral comments about science and scientists, such as: “(science is) proving or disproving theories,” and “they answer questions.” Some ambiguous comments from Group B included “they had mustaches” and “one guy smelled like soap.” Group A had more obviously positive comments (eight positive comments) than Group B (four positive comments) in the post interview. Before the treatment, both Group A’s school and Group B’s school disagreed with the statement *Scientists are less friendly than other people,* in the Modified Test of Science Related Attitudes. Most schools disagreed with this statement, but Group A’s school and B’s school had a higher mean. In other words, they did not disagree as strongly as the other
schools. Group A’s school showed a very significant shift towards disagreeing with the statement after the treatment (pre-treatment mean of 2.75 to post-treatment mean of 1.938, p=.0271). Several significant changes in the students’ attitudes were observed in the students’ responses to the Modified Test of Science Related Attitudes. Statements of particular interest are shown in the table below for the entire sample of students (Table 2).

Table 2

<table>
<thead>
<tr>
<th>Statement</th>
<th>Pre-Mean</th>
<th>Post-Mean</th>
<th>Change</th>
<th>P Value</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientists are less friendly than other people*</td>
<td>2.050955</td>
<td>1.745223</td>
<td>*- 0.288</td>
<td>0.0001</td>
<td>157</td>
</tr>
<tr>
<td>I use science to solve problems in my own life</td>
<td>3.151899</td>
<td>3.449367</td>
<td>0.297</td>
<td>0.0005</td>
<td>158</td>
</tr>
<tr>
<td>I use science to discover truth about natural and man-made things.</td>
<td>3.4</td>
<td>3.65</td>
<td>0.250</td>
<td>0.0012</td>
<td>160</td>
</tr>
<tr>
<td>Materials science may help solve our energy problems</td>
<td>3.751592</td>
<td>4.006369</td>
<td>0.255</td>
<td>0.0014</td>
<td>157</td>
</tr>
<tr>
<td>Scientists and engineers try to discover truth about natural and man-made things</td>
<td>3.948718</td>
<td>4.128205</td>
<td>0.255</td>
<td>0.0236</td>
<td>156</td>
</tr>
<tr>
<td>I believe I have the ability to become a scientist</td>
<td>3.654088</td>
<td>3.798742</td>
<td>0.145</td>
<td>0.0441</td>
<td>159</td>
</tr>
</tbody>
</table>

*For a negatively worded question, a decrease is a positive result.

**INTERPRETATION AND CONCLUSION**

The significant changes in several items on the Modified Test of Science Related Attitudes are very encouraging. Among these items were those we felt were most central to the goals of the *Making Stuff at Princeton* program. They show gains in students
seeing themselves as scientists, what scientists do, and the role materials science plays in solving the problems we and these students are facing and will continue to face in our lifetime.

We saw an increase in three statements alluding to the nature of science as a tool to “discover truth about natural and manmade things” and using science to solve problems, both as something scientist and engineers do and something the students do as well. This may mean that, as a result of their participation in the program, students have a better understanding of what science is and that it is a tool that they can use themselves.

We also wanted to show students that scientists are approachable, real people not unlike themselves. The significant changes seen in students’ responses to the statements Scientists are less friendly than other people and I believe I have the ability to become a scientist indicate we may have had a significant positive impact in how students perceive scientists and that they themselves can follow the same path if they choose.

Making Stuff at Princeton was similar to an event we have conducted before called the Science and Engineering Expo. The Expo, however, was a collaborative effort with other science departments. While there was a strong materials science component, Making Stuff at Princeton was almost purely focused on the topic of materials science. In previous work studying the 2009 Science and Engineering Expo, we showed a significant increase in students’ agreement with the statement Materials science may help solve our energy problems, (Pre-mean 3.81, Post-mean 3.96, P = 0.02, N=372) (Steinberg & Greco, 2009). A greater increase in agreement with the same statement was shown after exposure to the materials science-focused Making Stuff at Princeton (Pre-mean
3.751592, Post-mean 4.006369, P = 0.0014, N=157). This makes sense because the program was more focused on materials science.

Four of the nine the teachers in the Teacher Focus Group Interview reported that they had introduced their students to scientists; however one reported that the scientist had been at a science center. While it is possible that the person was a scientist presenting at the science center, it is also possible the teacher assumed the person was a scientist. Similarly, we cannot know for sure whether the students are accurately reporting how many scientists and engineers they have met. In the interviews, some students assumed their own teachers were scientists, perhaps because they learn science from them. Interestingly, in Group A’s pre-treatment Student Focus Group Interview, three students felt they had met engineers, but upon further probing, it became clear that two of those students were talking about car mechanics. It may be possible that some of those who reported that they had met engineers (61.3%, N=204) in the Modified Test of Science Related Attitudes had not in fact met engineers.

The teachers’ claims of students’ like of science was supported in the students’ responses in the interviews and the surveys, but the misconceptions they offered as possibilities for their students were not supported. In fact, based on the analysis of the data, teachers poorly predicted the misconceptions that might surface in the study on the topics of science and scientists. No students said anything about scientists being geeky, though some did mention awkward after the treatment. Though the few students who commented about the social awkwardness of one or two scientists are likely not representative of the entire sample’s views, it is important to note that the comments came after the treatment. The comments were made about a few specific scientists after a
real interaction, and it may simply be the students’ perception of the persons in question rather than a misconception about all scientists. The teachers’ impression that their students lack confidence is cause for concern as it may lead to lower achievement (Fraser, 2007; McGarrigle, 2005). However, we should take care not to encourage confidence at the price of the misconception that science is purely about knowing the answers (another concern of the teachers). This sentiment is perhaps present in the student’s comment from Group B’s post interview, “I like science because it makes me feel unique when I know something that other people don’t.” Future work may present the opportunity to explore students’ misconceptions about science further.

It appears that most of the students participating in the study do indeed tend to like science at this age (grades 6-8) as exhibited by their high pre- and post-treatment responses in the Modified Test of Science Related Attitudes. One would hope this is true of other students outside the study. If it is true, as the literature suggests, that students tend to lose interest in science and engineering during middle school, we have some evidence indicating that events like Making Stuff at Princeton can help maintain or even increase their attitudes towards science and scientists in the middle school years.

VALUE

Conducting this study showed that a one-day event featuring direct interaction with scientists showcasing their work with help from education outreach professionals can significantly improve the attitudes of middle school students towards science and scientists. The results support the continuation of such programs. Based on these results, I believe we have evidence that these programs have great value for students, especially
for those who have little access to real scientists. Properly constructed programs, properly selected and trained scientists and engineers, and well-planned activities designed to complement each other can lead to improved student attitudes. This one exposure had a significant impact; however there is such great need that there is always more work to be done in improving students’ attitudes and achievement in science and engineering. Perhaps more work can be done with students who attend such programs in follow-up activities, either professional development for the teachers or content centered programs for the students, to make use of the improved attitudes towards science and scientists. If all universities conducted programs like this with the same quality (of course, it is possible to run a bad program and turn students away from science), we could have a huge positive impact on this country’s performance in STEM fields by improving students’ attitudes towards STEM.

This project has provided me with an opportunity to systematically evaluate one of our programs and refine a process of reporting the impact of the program. I realized that it was very important to me that the program meet its goals. At times during initial analysis, due to errors such as comparing one school’s pre-treatment results to another’s post-treatment results, the data showed very disappointing results. I experienced tremendous relief when the errors were corrected during my consultations in Princeton University’s Data Lab (a service provided to staff and students of the University). At one point, the pre- and post-results were not matched correctly, and the statistician I consulted said smugly, “Ah, your program had no impact.” When the error was corrected, I proudly reported to him that there were significant changes in many of the areas that the program was designed to improve. I also learned to check my data and analysis over and
over with a critical eye, even when everything came out as expected. All data in this project have now been corrected.

I see the importance of a mixed-method approach to data collection as the confirmation and contradiction can tell a much richer story. I have learned how to interpret the data and draw conclusions. This is important for my own growth as a professional and to evaluate the impact of my work. These skills will serve me well in my career in informal science education.
REFERENCES CITED


APPENDIX A

MODIFIED TEST OF SCIENCE RELATED ATTITUDES
Modified Test of Science-Related Attitudes

Tear-Off Sheet

Name: 
School: 
Grade: 
Gender (circle one): 
Male  Female

Ethnicity (circle all that apply): 
African American  Hispanic/Latino  White 
Asian/Pacific Islander  Native American  Other: __________________

Unique Identifier:  1

Note: This sheet will be removed prior to analysis and kept separately, only to match pre-event responses with post-event responses. For example, if you complete survey number 8 prior to the event and completed survey number 27 following the event, the operator will only know that pre-survey 8 and post-survey 27 are the same person. The operator will not know the name of the person who completed the survey.

Identification of all students involved will be kept strictly confidential. There are no foreseeable risks or ill effects from participating in this study. This survey is completely voluntary and no student will be denied admission to the Making Stuff event or any other event for not completing the survey. Furthermore, participation in the study can in no way affect grades for any course, nor can it affect academic or personal standing in any fashion whatsoever. This information will allow us to continue providing experiences like Making Stuff to students. It will also help me in my own growth as a science education professional.

Participation in this study is voluntary, and students are free to withdraw consent and to discontinue participation in this study at any time without prejudice from the investigator. Please feel free to ask any questions of Shannon Greco via e-mail, phone, or in person before signing the Informed Consent form and beginning the study, and at any time during the study.

Please sign if you agree to take this survey and allow your responses to be included in the study.

Student’s signature: ___________________________

Date: _____________________
Please rate your level of agreement with the following statements by circling the letter(s) in the appropriate column.

Example Statement:
I like fuzzy blue socks.

1. I enjoy meeting real scientists
2. I would like to learn more about materials science
3. When I graduate school, I would like to work with people who make discoveries in science
4. I use science to solve problems in my own life
5. I like science
6. I am curious about polymers
7. I like to figure out how things work
8. Learning new things is unimportant
9. Materials science may help solve our energy problems
10. Scientists and engineers try to discover truth about natural and man-made things
11. Working in a science laboratory would be an interesting way to earn a living
12. Scientists are less friendly than other people
13. I have questions I'd like to ask an engineer or scientist
14. Science is one of the most interesting subjects

Continued on reverse side…
Continued from front side

15 Talking to my friends about science after school would be boring
16 I use science to discover truth about natural and man-made things.
17 It would be fun to teach science
18 Science does not help to make life better
19 I am concerned about climate change
20 Science can help to make the world a better place in the future
21 I would not like to become a scientist
22 If you met a scientist, he/she would probably look like anyone else you might meet
23 I do not enjoy learning new things in science
24 Women are as good at science as men
25 It is important for me to learn science
26 I would like a job that uses science
27 I believe I have the ability to become a scientist
28 I want to keep learning about science when I grow up.
29 I think I would make a good scientist when I grow up.
30 I am less interested in science than I was when I was in elementary school.

31 Have you ever met a scientist?  Yes  No
32 Have you ever met an engineer?  Yes  No

This is the end of the survey.
APPENDIX B

FOCUS GROUP INTERVIEW QUESTIONS FOR TEACHERS
Focus Group Interview Questions for Teachers

1. What is your impression of your students’ attitudes towards science in general?

2. From your own observations or discussions with colleagues, how does that compare to their attitude towards other subjects in school?

3. What are some misconceptions you often see in your students about the nature of science?

4. What about misconceptions about scientists?

5. To your knowledge, have any of the students met a scientist or engineer?

6. Would it be a positive thing to introduce them to a scientist or engineer? Why or why not?

7. Do you introduce the students to careers in science? If so, how?

8. Is there anything else you would like to tell me?
APPENDIX C

FOCUS GROUP INTERVIEW QUESTIONS FOR STUDENTS
Focus Group Interview Questions for Students

Student Focus Group Interview Questions

1. Have you ever met a scientist or engineer?
   a. If so, what was he or she like?
   b. If not, what are scientists like?
   c. Did you learn anything from him or her?
   d. Do you wish they had told you anything else?
2. What do scientists do?
3. Can you tell me what science is?
   a. Is science more than what you learn in school?
   b. How is science used?
4. Tell me about what science is like when it’s not part of school.
5. Have you ever solved a problem or figured out why or how something works?
6. Do you like science?
   a. Why or why not?
7. Do you like science when it’s not part of school? (Clarification if necessary: Like on TV or in books or doing an experiment for fun?)
APPENDIX D

AUTHORIZATION LETTER TO CONDUCT STUDY
Authorization Letter to Conduct Study

The purpose of this research project entitled "Impact of Interaction with Scientists and Engineers at Making Stuff," examines the impact, whether positive or negative, of middle school students’ interaction with materials science and engineering faculty, staff and students at a one-day event (Making Stuff at Princeton University, January 27, 2011). For this project, students will be asked to complete the Modified Test of Science Related Attitudes (MTOSRA, pre-event and post-event) and the Student Focus Group Interview (pre-event and post-event). All of these data collection instruments fall within the area of common education outreach evaluation practices.

Identification of all students involved will be kept strictly confidential. Most of the students involved in the research will remain unidentified in any way, and their levels of environmental interaction will be assessed and noted. The students will be assigned identifiers for the pre- and post-event MTOSRA. Names will be removed from the surveys using a tear-off sheet prior to analysis and will only be used to link pre-event identifiers and post-event identifiers. Student Focus Group Interviews will be conducted in classes that allow video-taping with permission from schools. Recordings will only be used for the purposes of this study and will not be published. Nowhere in any report or listing will students’ last name or any other identifying information be listed.

There are no foreseeable risks or ill effects from participating in this study. Princeton University’s Institutional Review Board approval is pending for this study, but there is no reason to suspect approval will not be granted. All treatment and data collection falls within what is considered normal education outreach instructional practice. This survey is completely voluntary and no student will be denied admission to the Making Stuff event or any other event for not completing the survey. Furthermore, participation in the study can in no way affect grades for any course, nor can it affect academic or personal standing in any fashion whatsoever.

There are several benefits to be expected from participation in this study. We have always asserted that research scientists and engineers can positively impact science education, students’ career aspirations in STEM fields, and public support for science research. This study will help us prove it. This study will help us improve Making Stuff and ensure that we are contributing positively towards students’ appreciation of science and engineering. This information will allow us to continue providing experiences like Making Stuff to students. It will also help me in my own growth as a science education professional.

Participation in this study is voluntary, and students are free to withdraw consent and to discontinue participation in this study at any time without prejudice from the investigator. Please feel free to ask any questions of Shannon Greco via e-mail, phone, or in person before signing the Authorization Letter form and beginning the study, and at any time during the study.

School name: ___________________________

Principal’s name: ___________________________

Principal’s signature: ___________________________

Date: ______________________

Researcher contact: Shannon Greco, sgreco@princeton.edu, 609-258-8830
APPENDIX E

INFORMATION LETTER FOR PARENTS OF STUDENTS IN THE STUDY
Information Letter for Parents of Students in the Study

The purpose of this research project entitled "Impact of Interaction with Scientists and Engineers at Making Stuff," examines the impact, whether positive or negative, of middle school students’ interaction with materials science and engineering faculty, staff and students at a one-day event. For this project, students will be asked to complete the Modified Test of Science Related Attitudes (MTOSRA, pre-event and post-event) and the Student Focus Group Interview (pre-event and post-event). All of these data collection instruments fall within the area of common education outreach evaluation practices.

Identification of all students involved will be kept strictly confidential. Most of the students involved in the research will remain unidentified in any way, and their levels of environmental interaction will be assessed and noted. The students will be assigned identifiers for the pre- and post-event MTOSRA. Names will be removed from the surveys using a tear-off sheet prior to analysis and will only be used to link pre-event identifiers and post-event identifiers. Student Focus Group Interviews will be conducted in classes that allow video-taping with permission from schools. Recordings will only be used for the purposes of this study and will not be published. Nowhere in any report or listing will students’ last name or any other identifying information be listed.

There are no foreseeable risks or ill effects from participating in this study. All treatment and data collection falls within what is considered normal education outreach instructional practice. This survey is completely voluntary and no student will be denied admission to the Making Stuff event or any other event for not completing the survey. Furthermore, participation in the study can in no way affect grades for any course, nor can it affect academic or personal standing in any fashion whatsoever.

There are several benefits to be expected from participation in this study. We have always asserted that research scientists and engineers can positively impact science education, students’ career aspirations in STEM fields, and public support for science research. This study will help us prove it. This study will help us improve Making Stuff and ensure that we are contributing positively towards students’ appreciation of science and engineering. This information will allow us to continue providing experiences like Making Stuff to students. It will also help me in my own growth as a science education professional.

Participation in this study is voluntary, and students are free to withdraw consent and to discontinue participation in this study at any time without prejudice from the investigator. Please feel free to ask any questions of Shannon Greco via e-mail, phone, or in person before signing the Informed Consent form and beginning the study, and at any time during the study.

If you do NOT want your child to participate in this study, please sign and return this form. Even if I do not receive this form from you, your child will still have the opportunity to decline to participate.

Child’s name: ___________________________

Parent’s name: __________________________

Parent signature: ________________________

Date: ______________________
APPENDIX F

INFORMATION LETTER FOR PARENTS OF STUDENTS IN THE STUDY
(OPT-OUT)
Informed Consent Form for Parents of Students in the Study

The purpose of this research project entitled "Impact of Interaction with Scientists and Engineers at Making Stuff," examines the impact, whether positive or negative, of middle school students’ interaction with materials science and engineering faculty, staff and students at a one-day event. For this project, students will be asked to complete the Modified Test of Science Related Attitudes (MTOSRA, pre-event and post-event) and the Student Focus Group Interview (pre-event and post-event). All of these data collection instruments fall within the area of common education outreach evaluation practices.

Identification of all students involved will be kept strictly confidential. Most of the students involved in the research will remain unidentified in any way, and their levels of environmental interaction will be assessed and noted. The students will be assigned identifiers for the pre- and post-event MTOSRA. Names will be removed from the surveys using a tear-off sheet prior to analysis and will only be used to link pre-event identifiers and post-event identifiers. Student Focus Group Interviews will be conducted in classes that allow video-taping with permission from parents. Recordings will only be used for the purposes of this study and will not be published or viewed by anyone other than the author of the study. The purpose of the recording is only to ensure accurate data collection. Nowhere in any report or listing will students’ last name or any other identifying information be listed.

There are no foreseeable risks or ill effects from participating in this study. All treatment and data collection falls within what is considered normal education outreach instructional practice. This survey is completely voluntary and no student will be denied admission to theMaking Stuff event or any other event for not completing the survey. Furthermore, participation in the study can in no way affect grades for any course, nor can it affect academic or personal standing in any fashion whatsoever.

There are several benefits to be expected from participation in this study. We have always asserted that research scientists and engineers can positively impact science education, students’ career aspirations in STEM fields, and public support for science research. This study will help us prove it. This study will help us improve Making Stuff and ensure that we are contributing positively towards students’ appreciation of science and engineering. This information will allow us to continue providing experiences like Making Stuff to students. It will also help me in my own growth as a science education professional.

Participation in this study is voluntary, and students are free to withdraw consent and to discontinue participation in this study at any time without prejudice from the investigator. Please feel free to ask any questions of Shannon Greco via e-mail, phone, or in person before signing the Informed Consent form and beginning the study, and at any time during the study. Even if I do receive a signed form from you, your child will still have the opportunity to decline to participate if he or she chooses.

Permission: I hereby grant Shannon Greco permission to include my child in this study:
Child’s name: ___________________________

Parent’s name: ___________________________

Parent signature: ___________________________

Date: ______________________

Please check here if you also agree to the video recorded group interview:

☐ Video Recorded Group Interviews (Pre- and Post-event; see above statement of use)
APPENDIX G

INFORMED CONSENT FORM FOR STUDENTS IN THE STUDY
Informed Consent Form for Students in the Study

The purpose of this research project entitled "Impact of Interaction with Scientists and Engineers at Making Stuff," examines the impact, whether positive or negative, of middle school students’ interaction with materials science and engineering faculty, staff and students at a one-day event.

Before and after Making Stuff at Princeton University, I may interview you and your class in Student Focus Group Interviews (pre-event and post-event). The interview is a common education outreach evaluation practices.

Identification of all students involved will be kept strictly confidential. Most of the students involved in the research will remain unidentified in any way, and their levels of environmental interaction will be assessed and noted. Student Focus Group Interviews will be conducted in classes that allow video-taping with permission from parents. Nowhere in any report or listing will students’ last name or any other identifying information be listed.

There are no foreseeable risks or ill effects from participating in this study. All treatment and data collection falls within what is considered normal education outreach instructional practice. This interview is completely voluntary and no student will be denied admission to the Making Stuff event or any other event for not completing the interview. Furthermore, participation in the study can in no way affect grades for any course, nor can it affect academic or personal standing in any fashion whatsoever. Nothing bad will happen at all based on your choice to complete the interview or not. Nothing bad will happen based on your choice to participate in the interviews or not.

There are several benefits to be expected from participation in this study. We have always asserted that research scientists and engineers can positively impact science education, students’ career aspirations in STEM fields, and public support for science research. This study will help us prove it. This study will help us improve Making Stuff and ensure that we are contributing positively towards students’ appreciation of science and engineering. This information will allow us to continue providing experiences like Making Stuff to students. It will also help me in my own growth as a science education professional.

Participation in this study is voluntary, and students are free to withdraw consent and to discontinue participation in this study at any time without prejudice from the investigator. Please feel free to ask any questions of Shannon Greco via e-mail, phone, or in person before signing the Informed Consent form and beginning the study, and at any time during the study.

School’s name: ___________________________

Student’s name: __________________________

Student’s signature: __________________________

Date: __________________________

Researcher contact: Shannon Greco, sgreco@princeton.edu, 609-258-8830
APPENDIX H

INFORMED CONSENT FORM FOR TEACHERS IN THE STUDY
Informed Consent Form for Teachers in the Study

The purpose of this research project entitled "Impact of Interaction with Scientists and Engineers at Making Stuff," examines the impact, whether positive or negative, of middle school students’ interaction with materials science and engineering faculty, staff and students at a one-day event. For this project, teachers will be asked to complete the Teacher Focus Group Interview (pre-event and post-event). All of these data collection instruments fall within the area of common education outreach evaluation practices.

Identification of all teachers involved will be kept strictly confidential. Teacher Focus Group Interviews will be conducted and video-taped in Bowen Hall. Nowhere in any report or listing will teachers’ last name or any other identifying information be listed.

There are no foreseeable risks or ill effects from participating in this study. All treatment and data collection falls within what is considered normal education outreach evaluation practice. This survey is completely voluntary and no student or teacher will be denied admission to the Making Stuff event or any other event for not participating in the interview. Furthermore, participation in the study can in no way affect grades for any course, nor can it affect academic or personal standing in any fashion whatsoever.

There are several benefits to be expected from participation in this study. We have always asserted that research scientists and engineers can positively impact science education, students’ career aspirations in STEM fields, and public support for science research. This study will help us prove it. This study will help us improve Making Stuff and ensure that we are contributing positively towards students’ appreciation of science and engineering. This information will allow us to continue providing experiences like Making Stuff to students such as yours. It will also help me in my own growth as a science education professional.

Participation in this study is voluntary, and teachers are free to withdraw consent and to discontinue participation in this study at any time without prejudice from the investigator.

Please feel free to ask any questions of Shannon Greco via e-mail, phone, or in person before signing the Informed Consent form and beginning the study, and at any time during the study.

School’s name: ___________________________

Teacher’s name: ___________________________

Teacher’s signature: ________________________

Date: ______________________

Researcher contact: Shannon Greco, sgreco@princeton.edu, 609-258-8830
APPENDIX I

ETHICS STATEMENT
Ethics Statement

I, Shannon Greco, am undertaking an action research project to study my own practice as a science education outreach professional. The purpose of the research is to improve our strategies to help our programs inspire and educate students in science and engineering. The nature of the research involves the application of various evaluation strategies common to science education outreach programs, including group interviews, various forms of formative and summative assessment, and written and verbal surveys to acquire student input concerning their learning and their feelings about the science education outreach program. This ethics statement is to assure you that I will observe good ethical practice throughout the research.

Good ethical practice during action research means that I will negotiate permission to conduct the research, respect confidentiality such that no names will be attached to any data or observations, and only summary data and quotes will be used in the final report, participants will be kept informed of progress, and all participants will have the right to withdraw from the research at any time with no adverse effect on their participation in Making Stuff or any other programs at Princeton University.

Signed___________________________________________

Shannon Greco
609-258-8830
sgreco@princeton.edu