HOSTING PROFESSIONAL SCIENTISTS IN THE CLASSROOM:

THE EFFECT ON RURAL SIXTH GRADERS'

ATTITUDES TOWARD SCIENCE

by

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ABSTRACT

In this study scientists were invited into the classroom over a two month period to measure change in students' perceptions of scientists, their willingness to pursue a scientific career, and how they value science. As shown on the Draw-A-Scientist Test, Test of Science Related Attitudes, and student journals, positive change did occur regarding students' perceptions of scientists, their attitudes toward the value of science, and science as a career.

INTRODUCTION AND BACKGROUND

I teach sixth grade in a self-contained classroom of sixteen students at Superior Elementary School in Superior, Montana. Our building houses grades kindergarten through sixth as well as a part-time pre-school which brings our total number of students to around 140. Superior is located in northwestern Montana and has a highly transitory population. Many of the students passing through my door this year have changed schools two or three times within the past few years. Children at our school demonstrate resiliency given challenges they face, which vary from frequent moves, to economic hardship, to learning disabilities. On average, this class is one of the lowest achieving classes that I've experienced in over eleven years of teaching. In spite of the high transitory rate, this is not an ethnically diverse class as 94% of my students are Caucasian (Kinney, 2012).

Because of our high transitory rate, our school receives students who have changed schools frequently over the course of their education. This results in many gaps in their core subjects. Therefore, for the past five years, our focus has been on helping these lower achieving students catch up to their peers. Our staff works hard to monitor students' progress in reading and math in order to employ early intervention when necessary. This means that we double dose those students who need extra help in order to bridge their learning gaps. The goal is to eventually graduate them out of the intervention program and place them back into the regular educational setting. This has been hugely successful in getting our students on the right track, and we see fewer and fewer students being left behind in reading and math. Since I teach in a self-contained classroom, I teach nearly all of these students in most subject areas. However, some of my students get pulled out frequently to double dose in their core subjects. Rather than short-change a few of my students from missing science and social studies, I chose to have shorter classes of science (40 minutes) and social studies (30 minutes) so that all my students get those two subjects every day.

In science class, we have studied Bernoulli's Principle of lift. We used simple materials like index cards and paper cups to discover how increased air speed creates lower air pressure. I began this unit with an assessment probe (Appendix A) to determine my students' misconceptions, and then I administered the same probe at the end of the unit to reveal students' understandings and changes in misconceptions. We finished the unit with a flying field trip with the Young Eagles Pilots who fly in to our local airport in order to give the kids real flight experience.

By the time they reach my classroom, my sixth grade students have already established their ideas regarding the relevance of science in their own lives. Even though most students are excited to do experiments in my class, the trend I've observed is that a majority of sixth graders do not see science as relevant to their future. They carry this notion with them throughout their school career and it is very limiting to their enjoyment of science, their perceptions of solving global problems, and their own career choices. Once the false stigma of *what is a scientist* is peeled away, the ability of the students to understand the truth of their own interests should shine through.

This led to the purpose of this action research based project which was to determine whether inviting scientific specialists into the classroom changed students' views of scientists. In particular, will students' perceptions regarding scientists change to be more realistic? Two sub-questions were also explored.

- If students start to see scientists as real people who have interesting lives, will their willingness to pursue a scientific career increase?
- Will the experience with scientists help students to see the value of science in our world?

CONCEPTUAL FRAMEWORK

Science has dominated the headlines over the past few years with topics such as solving the energy crisis and global warming. In light of this, most Americans believe that science is important. In fact, 90% of Americans agreed with the statement, "because of science and technology, there will be more opportunities for the next generation" (National Science Foundation, 2009). Furthermore, when compared to countries such as South Korea, China, and many countries in Europe, Americans tend to place a higher priority on the importance of "new scientific discoveries" and "use of new inventions and technologies" (National Science Foundation, 2009, p. 4). However, there is a real disconnect for college-bound students. They consider science important in solving real world problems, yet many are not choosing a science related field as a career. In spite of increased interest in solving global science issues, career interest in science, technology, engineering, and mathematics (STEM) has been dropping among American college students. In 2007, fewer than 16% of all bachelor's degrees awarded were STEM related. That number has continued to drop. This dismal statistic puts us in 27th place among the 29 developed countries that participated in the study (Carnevale, Smith, & Strohl, 2010).

This lack of interest in science-related occupations can be traced back to middle and high school students who feel that science is fun, but don't see it as a career option. It has been documented that this attitude toward pursuing STEM careers is set between the ages of 10-14 when students' attitudes toward science drastically decline (Archer, Dewitt, Osborne, Dillon, & Willis, 2010). "Intermediate (middle) school students expressed significantly more negative attitudes [toward STEM careers] than did either elementary or high school students" (Greenfield, 1997, p. 261). Wigfield et al. (1991) found that sixth grade is the time in students' lives when their self-esteem is the highest. After that time, during the transition to junior high is when students' attitudes decline the most. This data suggests that the elementary school years are a critical time to promote scientific career interest for American students before their attitudes shift.

In spite of scientific topics dominating the media, students still hold stereotypical images of what characterizes a scientist. The "draw-a-scientist" task continues to be a window into what misconceptions students still hold about scientists (Chambers, 1983). The misconception that scientists are brainy, nerdy, lab-coat wearing madmen who stay sequestered alone in their labs still prevails among middle schoolers even in the 21st century (Spindler, 2010). This makes the scientific field seem so disparate from their own lives, it is a wonder that any middle school student would even consider science as a career field. Combine these ridiculous, stereotypical visions of scientists with the fact that many students have never had a scientist visit their classroom, and it becomes even more obvious why student interest in science is dropping. In a 2006 middle school classroom study, less than 10% of the students ever had a classroom visit from a scientist even though the school was located near many industries specializing in scientific areas (Painter, Jones, Tretter, & Kubasko, 2006).

Parental influence is another link to student attitudes. As parents shape their children's interest in multiple ways, the role that parents play in affecting how their child views science cannot be overstated. Surprisingly, the learning goals of most adolescents are more connected to their mothers' aspirations for them than to the goals of their best friends (Andre, Whigam, Hendrickson, & Chambers, 1999). For example, if parents show an interest in scientific television shows, news broadcasts, etc., there is a direct link to an increase in student interest as well (Jones, Howe, & Rua, 2000). This increased background knowledge that the parents provide is connected to an increased pursuit of scientific careers by children raised in scientifically literate homes (Andre et al., 1999).

While parents can play a positive role in raising future scientists, unfortunately the opposite is also true. Even though many Americans feel that science is important to our future, this often does not translate to parents feeling that science class is as important as other classes. In a 1998 study regarding the ideas parents hold about science, parents believed reading to be the most important subject with math ranked second and science third. There has not been significant research to discover how parents respond to their children when homework in different subjects is brought home. Furthermore, there has been little research to see how a parent responds when a child brings home a poor grade in math versus a poor science grade. This continues to be a variable requiring more research (Andre et al., 1999).

Yet another reason students become disenchanted with science careers is their own perceived lack of science competency. When a study was conducted on middle school students' perceptions regarding their own competency in science, a majority of students perceived themselves to be less competent in science compared to other subjects.

This creates a self-fulfilling prophecy related to students' feelings of inadequacies toward science. This perceived lack of proficiency can be detrimental to students' attitudes toward doing science in school as well as in life (Andre et al., 1999).

Students' attitudes toward science even factor in as far as our global future is concerned. Poor attitudes even by students who do not plan to pursue careers in science may still affect how they view science as adults. This can lead to citizens who are not scientifically literate. Scientific literacy is important to our daily functioning as we need a basic scientific background to "solve problems creatively, think critically, work cooperatively in teams, and use technology effectively" (Akcay & Yager, 2010, p. 602). Society is getting more and more dependent on technology to use for everyday purposes. This rapid increase requires people to have some basic understanding of scientific principles and the scientific method (Fensham, 2006). Proper science instruction teaches students not just about content but about logical processes as well. American citizens who do not view science as relevant when they are voting on important legislation could vastly affect America's ability to compete in a global market (Feinstein, 2010).

With all these obstacles keeping students from pursuing science, it becomes the science teacher's responsibility to show students and parents the connection between science classes in school and solving 21st century problems in life. Teachers' days are already filled trying to fit in all the content required to meet today's revised standards. In grades 6-8 alone there are 157 essential learning expectations ("Montana K-12 Content," 2009). However, if these barriers are not overcome, the U.S. will not only have a future with fewer STEM occupations being undertaken but will also face a future where a vast majority of the population doesn't even value those professions (Andre et al., 1999).

Recent researchers have found that inviting scientists into the classroom is beneficial to changing these negative attitudes in spite of some difficulties. Educators have their work cut out for them, especially when starting up these classroom visits. The scientists who students find the most engaging could be brought back each year to visit, but teachers won't know how well professionals will interact with students until taking that first step (Cantrell & Ewing-Taylor, 2009). Another possible roadblock is simply maintaining these relationships with scientists and teachers who are already leading over-scheduled lives. Both the teacher and the scientist need to see this as a vital, worthwhile endeavor in order to continue working together in spite of their already busy lives (Rennie & Howitt, 2009).

When students understand that careers in scientific fields are relevant, they can begin to imagine themselves pursuing those careers. Students need to see science careers as "personally fulfilling, worthwhile, and rewarding" (Archer et al., 2010, p. 636). Cantrell, & Ewing-Taylor (2009) noted, "The fact that 90 percent of the students stated that the most important part of the program was learning about careers that they had not known existed is perhaps the most important finding of this study" (p. 299). However, in that study most of the high school participants had already chosen their career path. So, they concluded that it is vital to implement the series of speakers at an earlier grade level, or across several grade levels.

Likewise, students need to see scientists as balanced, real people who have interesting personal lives. This can be done through informal interactions as well as structured interactions and interviews. However, the biggest factor seems to be that students and scientists interact in meaningful ways. The students and the scientists need to become comfortable with each other to interact meaningfully. “It was during the social hours that students crowded around the speakers, asked questions, received more personalized experience with various apparatus and equipment, and talked informally about what it was like to do what the speaker did for a living. There were a number of evenings when the lights almost had to be turned out to inform students it was time to leave” (Cantrell & Ewing-Taylor, 2009, p. 300).

In a 2008 study, where scientists interacted with students in primary, middle, and high school, Rennie and Howitt found that these collaborations could have many positive effects. Students felt that they gained more content knowledge and understanding since they were learning from a practicing scientist, and the teachers felt that *their* content knowledge was also strengthened from the interaction. Moreover, the scientists also felt the experience to be beneficial. Ninety-six percent of participating scientists believed that the “opportunity to see scientists as real people” was the most significant benefit to students, with “increased knowledge of contemporary science” and “having fun” placing second and third. When surveyed about how the partnership benefitted them, 92% of the participating scientists ranked “opportunity to communicate with students” as the number one benefit with “enjoyment in working with students” and “opportunity to communicate with teachers” as the second and third ranked benefits. It was found that many high school students enjoyed the experience enough to characterize it as “fun.” This was found to be a vital outcome since most high school students are negatively inclined toward science. The conclusion of this study was favorable in that most students indicated that their negative preconceptions about both science and science-related careers had reversed (Rennie & Howitt, 2009).

METHODOLOGY

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained. During the two month treatment period, two female and one male scientist were invited to visit the sixth grade classroom. The visits occurred for one to two hours every other week in order to give interactive presentations to the sixteen students that I teach. The presentations were related to their scientific fields of study: astronomy, avalanche field study and medical lab work. Each presentation concluded with an interviewing period where students asked the scientist questions that were generated before the presentation as well as questions that arose during the presentation. Questions could be about the scientists' careers, family life, or their interests. Two scientists came in twice to allow the students and the scientists to develop a richer relationship. The intention was to open up the dialogue between students and scientists allowing the discourse to become less formal, so the students would see the scientists as *real people* not just eccentric, lab-coat wearing madmen with wild hair. During these encounters, I observed and videotaped students' interactions with the scientists and kept field notes in order to monitor students' attitudes as well as what questions they generated. Students also kept journals that included open-ended entries as well as guiding prompts (Appendix B).

To kick-off the project, I administered the draw a scientist test (DAST) and follow-up interview (Appendix C). This enabled me to determine the students' perceptions regarding the characteristics of scientists. I used the DAST checklist to keep track of student responses (Appendix D), and I compared the percentage of negative stereotypes that occurred in the pre-treatment DAST to the percentages that occurred in the DAST administered after the treatment. The students were simply asked to draw what they pictured in their heads upon hearing the word *scientist*. The students' responses to the test were surprisingly enthusiastic. One student actually said, "Yes! This will be fun!" When asked to raise their hands if they were interested in interviewing after they drew, almost all of the sixteen students raised their hands. They were given as much time as they needed, and as they finished, some of them were pulled out into the hallway one-by-one to interview (Appendix C). Eight students of varying performance levels were interviewed.

The next tool I used was the modified test of science-related attitudes or TOSRA (Appendix E). The TOSRA responses were first collected on paper and then students transferred their answers to the Classroom Performance Systems remote response units and submitted them electronically. The TOSRA helped to determine the students' attitudes toward scientific careers and the value of science in our world. To compare pre- and post-TOSRA responses, I looked for patterns regarding the percentage of change in each category.

After all pre-treatment data were collected, I began my treatment with the first visiting scientist, an astronomy professor at the University of Montana. We took a field trip and visited her campus for our first interaction. At the time, her department was hosting the star-lab planetarium, and she invited my students and me to participate in a demonstration. For our final visit with her she visited our classroom and did multiple astronomy simulations that demonstrate the interactions between stars and planets. Our next visiting scientist came from our local hospital laboratory department. First we visited his lab to see firsthand what he does for a living. During his next visit, he came to our classroom to do a computer simulation regarding viruses and bacteria. Our final visiting scientist was a local specialist in forestry science and avalanche awareness. She discussed with the class what she does for a living, how to avoid involvement with an avalanche, and how they rescue people who've been caught in one. She then discussed how we'd be working with her to maintain a tree farm in the spring.

After each visit students were asked to respond to prompts (Appendix B) in their journals. These prompts asked them to think back to their original DAST responses in order to modify or revise their original ideas. To analyze students' journal entries, I looked for key words that described scientists, science careers, and science in general. I watched for occurrences of negative and positive descriptions and calculated the percentages of occurrences from pre- to post-treatment. This and my other data collection techniques are summarized in Table 1.

Table 1
Data Triangulation Matrix

RESEARCH QUESTIONS	DATA SOURCE		
	1	2	3
Primary Question: 1. Will students' perceptions regarding scientists change to be more realistic?	Pre- and Post- DAST AND INTERVIEWS	TEACHER FIELD NOTES	OBSERVATIONS
Secondary Questions: 2. If students start to see scientists as real people who have interesting lives, will that increase their interest in science and willingness to pursue a scientific career?	Pre- and Post- TOSRA	STUDENT INTERVIEWS	STUDENT JOURNALS
3. Will the experience help students to see the value of science in our world?	Pre- and Post- TOSRA	STUDENT INTERVIEWS	STUDENT JOURNALS

DATA AND ANALYSIS

The DAST showed a significant change in how students perceive scientists. On the pre-treatment DAST, 50% of students drew scientists who had nerdy or crazy characteristics (N=16). These drawings showed at least one stereotypical characteristic like crazy hair or wild facial expressions. Some students emphasized this by writing the words "wacky" and "nerdy" next to their drawings. Conversely, on the post-treatment DAST, just one student drew a stereotypical Einstein-like person and 94% showed scientists with realistic appearances (a professional scientist at work not engaged in random science experiments) without any evidence of stereotypical characteristics.

Of the pre-treatment drawings where gender could be determined (*n*=10), 100% of students depicted a male scientist (Figure 1). On the post-treatment drawings where gender could be determined (n=14), 36% of students drew female scientists working alone, and 29% of the drawings depicted *both* male and female scientists working together or in two separate boxes working independently (Figure 2).

Of the 19% of pre-treatment drawings that depicted scientists in a more realistic profession, one showed a surgeon performing surgery, one showed a scientist holding a vial containing unknown chemicals, and one portrayed a scientist hunched over his microscope with giant serpentine tubes climbing to the ceiling. Even though these students drew scientists at work, only the surgeon seemed to be truly realistic showing a professional at work rather than a depiction of a crazed man throwing his hands up in the air. No pre-treatment drawings depicted scientists working outside, while 56% of post-treatment drawings showed scientists working outside studying avalanches, biology, forestry, or astronomy (Figure 1). One student said, “Some scientists are outside *all* the time.” She drew a biologist working in a field. In the post-treatment drawings where a scientist was shown working indoors, all but one depicted a realistic medical scenario that involved either lab work or surgery. As for pre-treatment outliers, two students drew equipment only with no actual scientists in the picture.

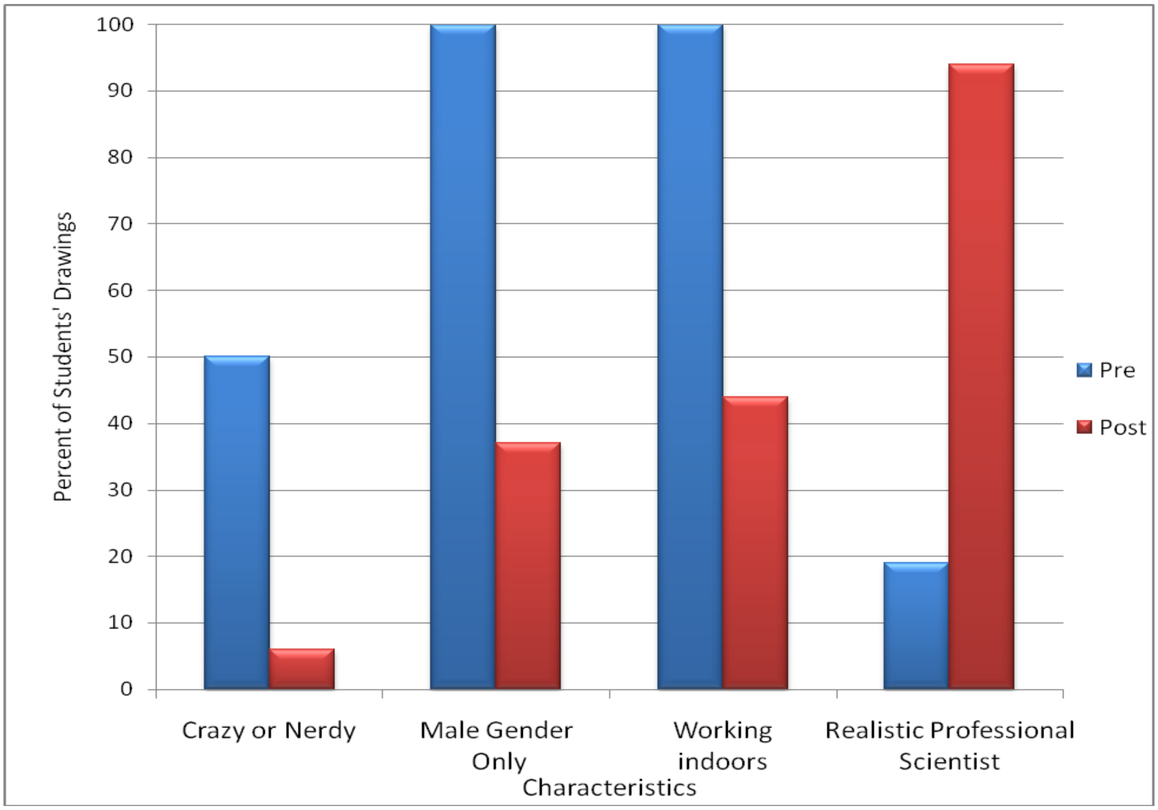

Figure 1. Draw a Scientist Results, (*N*=16).

The pre-treatment interviews revealed that 50% of students thought of Einstein when asked what the word *scientist* meant to them. One student said, “I drew Einstein because he’s the first thing I think of, but not all scientists look that way.” One student didn’t mention Einstein specifically, just a man in a lab coat with wild hair. During the post-treatment interviews, only one student still mentioned Einstein. He said he pictured “Einstein and spiky hair.” Other students said, “I picked one of the people we worked with,” and, “I took my idea from what we learned and drew a woman and a man working inside and outside.”

Figure 2. Typical Pre-Treatment Scientist Drawing.

One student depicted two scientists. One of the scientists was saying, “I make things go boom.” The other scientist replied, “I wonder what will happen if I mix these things together.” His drawings showed scientists at work, but doing randomly unproductive tasks. When I probed him further, he said, “[Scientists] mix stuff together just to see what happens.” This same student during the post-treatment interview said, “Scientists do their jobs to try to find an answer.” His post-treatment drawing realistically depicted a male and female scientist at work without any sign of randomly dangerous science experiments.

Figure 3. Typical Post-Treatment Scientist Drawing.

The TOSRA showed an overall increase in the positive responses toward science as a career. When all responses regarding science as a career were averaged, the change from pre-treatment to post-treatment was 31% in favor of science as a career. After the treatment, twenty-five percent more agreed or strongly agreed with each of the following statements: "When I leave school, I would like to work with people who make discoveries in science," "Working in a lab would be interesting," and "I would like to be a scientist when I leave school." Fifty percent more students agreed or strongly agreed with the statement, "A job as a scientist would be interesting" (Figure 4). After a visit from the astronomy professor, one student responded in her journal, "[Science] is cool and interesting to me. I would truly like to do science as my job!"

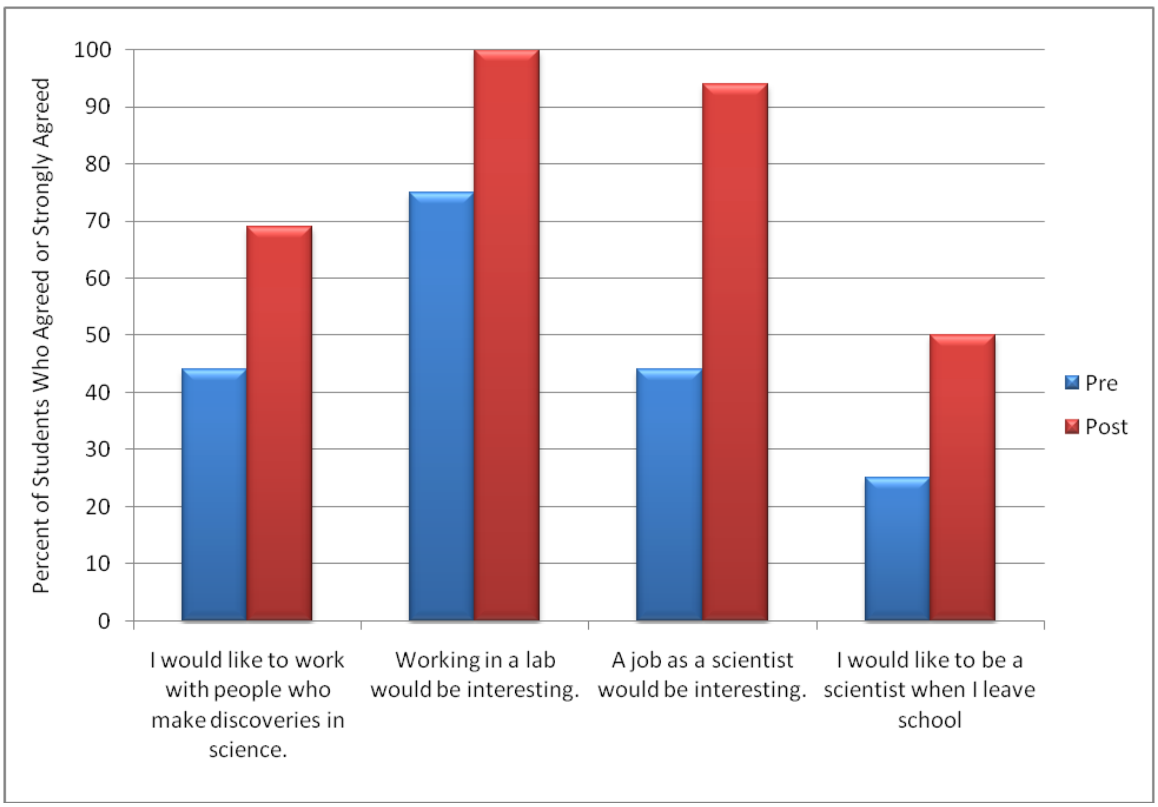

Figure 4. Science as a Career TOSRA Results, (*N*=16).

When eight of my students were asked during the pre-treatment interviews if they thought they would use science in their career, three students said probably, three said yes, one said they weren't sure yet, and one said no (Figure 5). Of the students who said yes or probably, two of them mentioned math, and the remaining answers were split evenly between botany, biologist, teacher, electronics, and unknown. The post-treatment interviews showed that one student changed from probably to yes, and another student changed from no to yes. One student also changed from probably to no because she now wants to be a fashion designer instead of a botanist. However, she still recognized that science is a part of that when she said, "Because math and science are related. In fashion you measure and you deal with variables."

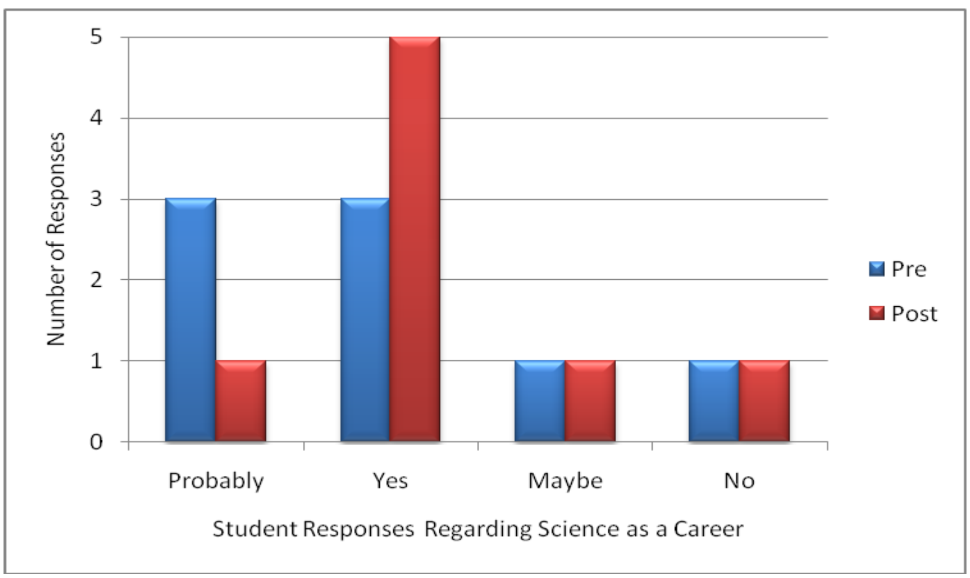

Figure 5. Science as a Career Interview Results, (*n*=8).

Students' journals indicated that their ideas changed regarding science as a career mostly because they didn't realize before the treatment how prevalent science is in our world. Ten students revealed this change in their journal responses. Five students had already mentioned an interest in using science in their careers (wildlife biologist, marine biologist, doctor, teacher), so their ideas didn't change. One student said his idea hadn't changed because he still had no idea what his career interests were. However, the other ten students overwhelmingly said they were unaware that science played a part in their career interests. One student wrote in her journal, "Now I realize that science is EVERYTHING from cooking to going into space."

Meeting the scientists proved to have a positive effect on my students' interest in science. The TOSRA showed that prior to meeting the scientists, 25% of my students felt they would like to belong to a science club compared to 63% who felt that way afterwards (Figure 6). Before the visits 69% of my students believed science was one of the most interesting school subjects, after the visits that number rose to 94%. One student said, "Before the visiting scientists, I thought that being a scientist would be boring, but now I see it could be fun and interesting."

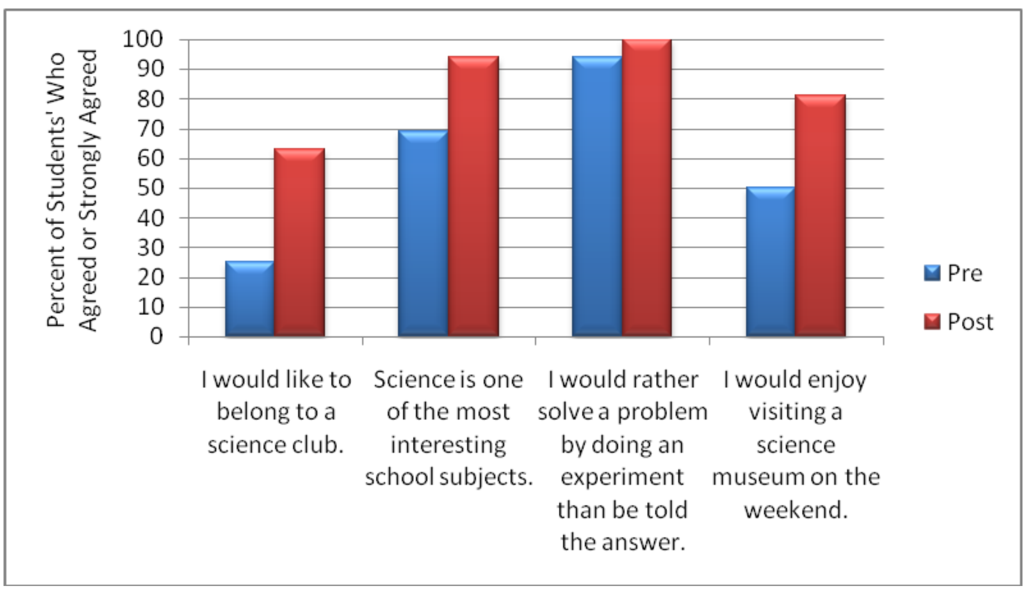

Figure 6. Interest in Science TOSRA Results, (*N*=16).

The responses from the eight students who were interviewed about the value of science changed slightly from pre-to post-treatment. When asked during the pre-treatment how scientists solve real-world problems, four of the students who were interviewed mentioned experimenting to figure out answers. Two said that scientists cure diseases and one student said scientists make things easier. After the treatment, all eight students named a specific way scientists solve problems in their interviews. These responses included: working on the cure for cancer, biology, using tools to make things easier, making discoveries, and inventing electronics (Figure 7).

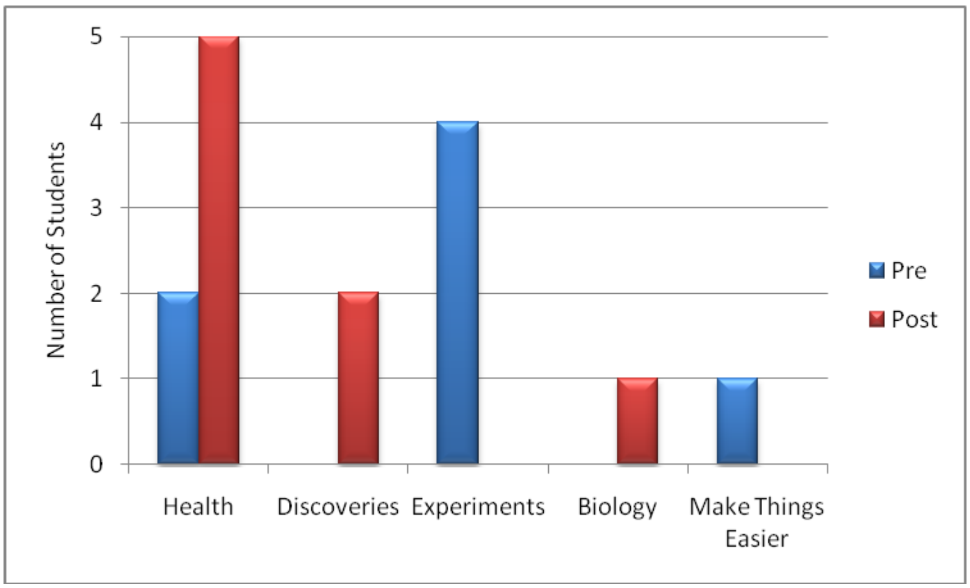

Figure 7. Value of Science Interview Results, (*n*=8).

After the treatment, student journals revealed another change in their ideas regarding how a scientist solves real-world problems. Before the treatment students' answers were generally correct, but vague regarding how scientists solve real-world problems. Most responses said simply, "Doing experiments," or "Using equations." Responses were not specific and the examples students gave were limited to what we had studied in our classroom. Most students wrote about levers and pulleys as that was what we were studying at the time. After the treatment, 15 out of 16 students mentioned at least one of the following: avalanche safety or rescue, wildlife or marine biology, discovering new planets, or saving lives and keeping us healthier. One student wrote, "They changed my perspective because now I know that they solve almost everything in life."

Student journals revealed that students' ideas regarding the value of science also changed to be more specific. Many students responded that they will use the knowledge they gained from the visiting scientists to be healthier and safer. After a visit from the lab technician who brought in samples of bacteria, one student wrote, "I will use the information to *not* get someone sick when I am sick." Another wrote, "I will use my knowledge by *not* going on bad, shaky, non-safe snow, and prevent getting stuck in an avalanche."

I also noticed that after the presentations, many students journals indicated that they were excited to tell others what they had learned. For example, one student wrote about, "…teaching people all about all the stars in the sky." After our meetings, students also mentioned how prevalent science is from cooking to electronics. For example, when asked how science affected his life, one student reported, "My dad does science when he works on his cars. He uses a jack to make it easier." Another student commented, "Science is everywhere!"

INTERPRETATION AND CONCLUSION

This study provides evidence that having students meaningfully interact with scientists can drastically change their perceptions of scientists to be more realistic and less stereotypical. These results are largely attributed to the fact that the students and scientists established a rapport (Cantrell & Ewing-Taylor, 2009). I do not think a one-time visit from an assortment of scientists would have had the same results. While the students were initially awkward toward the scientists, they gradually became comfortable enough to ask questions like: "What is your favorite song?" and "What is your favorite NFL team?"

After the treatment, my class almost unanimously drew realistic, mixed gender scientists. They also now regard scientists as regular people who do various jobs both indoors and outdoors. These results coincide with my experiences at the annual outdoor school which my students participate in at the end of every school year. We spend a week at a historic tree nursery interacting with scientists who are experts in their field and come out to share their knowledge with us. Every year after the camp I notice an increased enthusiasm for science as well as a more realistic view of scientists and their jobs. These initial observations led to this action research project.

While my students' ideas dramatically changed showing that they now recognize the presence of science in many careers, their ideas about pursuing a strictly scientific career did not change dramatically. However, many did mention that a scientific career would be fun. This was something I did *not* hear from them prior to conducting this study. Almost all of them indicated that they would use science in some capacity in their careers even though many still plan to pursue careers that are not scientific in nature. These results are hopeful, but not as clear as I'd hoped. Incorporating a more in-depth study of a wider range of scientific occupations may remedy this ambiguousness in the future. I feel that the question "Will you use science in your career?" should be changed to "Would you be interested in being a scientist, technician, engineer, or mathematician as a career?"

Even though the results regarding specific STEM careers were vague, I am encouraged by the fact that my students now appreciate that science is all around them. Before the treatment, many of my students expressed a reluctance to pursue *any* type of scientific career, but after the treatment they could acknowledge the presence of science in *all* careers. One student wrote in her journal, "Everything has something to do with science." This result is encouraging in regard to students valuing science. When students recognize the universality of science, they can begin to understand its importance in every aspect of their lives on this planet.

Almost all of my students indicated a change in their perception of how a scientist spends his or her day as well as what scientists do in their free time. The surprise that my students experienced at discovering that scientists have hobbies and real lives literally *pulled back the curtain* on my students' notions of scientists. Much like Dorothy and her friends' notion of the Wizard of Oz:

> "Toto (Dorothy's dog), smelling something funny in the angry Wizard's smoke, finds a curtain in the corner of the room. Toto pulls back the curtain to reveal a kind, flustered old man who is nothing like the image of the Wizard that had been projected" (Painter et al, p. 185).

VALUE

This project affected my students and my teaching in three main ways. The first benefit was an increased level of science content for both my students and me. Inviting experts into the classroom dramatically enhanced our level of science content understanding. Who better to teach my students about the universe than a respected astronomy professor? This student/scientist relationship concluded at this year's outdoor school where two of the three scientists visited us one last time for the school year to present on various outdoor topics.

The visiting scientists definitely added excitement to our classroom. After an initial awkwardness, the students were eager to interact with the scientists and looked forward to their visits. When I let the students know that the scientists would be visiting us again at outdoor school, the reaction was a unanimous, "Yay!" This enthusiasm for the visiting scientists had an added benefit of boosting my students' enthusiasm for science in general.

Finally, my teaching changed thanks to this experience. I no longer assume that my teaching is changing my students' attitudes or learning. I now look for *evidence* of change. Conducting surveys, utilizing different types of assessments, and regular observations are now part of my daily teaching practices. In the future I will carry action research into our annual outdoor school to measure its impact on my class by using many of the same data collection strategies I've discussed above.

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APPENDICES

APPENDIX A

BERNOULLI PROBE

Science
Bernoulli's Principle of Lift
Probe

Name________________________________

Three friends were noticing that on a windy day when our classroom windows are open, often paper will "suck" to the screen. They came up with the following ideas:

Melissa: "Paper is sticking to the screen because the wind is blowing *into* the classroom which causes it to go to the window."

Hailey: "Paper is sticking to the screen because the wind *outside* is creating less pressure. The paper is going towards the area of less pressure."

Makenzie: "Paper is sticking to the screen because the screen has static electricity, and it's giving its electrons to the paper."

With which student do you agree? ____________________________

Why? What "rule" did you use? _______________________________
____
____
____
____

APPENDIX B

JOURNAL PROMPTS

Open-ended prompts:

- Journal about your experience with today's visiting scientist.
- What would you like me to know about today's presentation?

Guiding prompts:

- What did you learn about from today's presenter about science?
- Did anything about today's presentation make you think differently about what a scientist looks like? How?
- Did anything about today's presentation make you think differently about how a scientist spends his/her day? How?
- How will you use the information and knowledge gained from our visiting scientists to enhance your own life?
- How will you use science in your everyday life?

APPENDIX C

DRAW A SCIENTIST TEST (DAST) & INTERVIEW QUESTIONS

Draw-A-Scientist Test

Draw what you picture when hearing the word “Scientist.”

After administering the Draw a Scientist Task, students will be asked:

1. How did you decide what to draw?
2. Is this what you picture in your mind when you hear the word ‘scientist’?
3. Do you think you will use science in your career?
    a. How?
4. How do scientists solve real-world problems?
    a. Can you give an example?
5. Is there anything else you’d like me to know?

APPENDIX D

DRAW A SCIENTIST TEST CHECKLIST (DAST-C)*

*Adapted from Barman, 1996; Jane, Fleer, & Gipps, 2007; Nuño, 1998

Draw a Scientist Checklist (DAST-C)

Indicators	Present (1)
LAB COAT	
EYEGLASSES OR GOGGLES	
FACIAL HAIR	
UNKEMPT APPEARANCE	
MALE GENDER	
CAUCASIAN ONLY	
MIDDLE AGED OR ELDERLY	
WORKING INDOORS	
INDICATIONS OF DANGER	
MYTHICAL STEREOTYPES (FRANKENSTEIN, JEKYLL/HYDE)	
SYMBOLS OF RESEARCH (scientific instruments, lab equipment)	
Types of instruments/ equipment	
SYMBOLS OF KNOWLEDGE (books, pens in pocket, filing cabinet)	
Symbols	
SCIENCE CAPTIONS ("eureka," formula, equations)	
Captions	
SYMBOLS OF TECHNOLOGY (phone, computer, TV, missiles)	
Type of technology	
INDICATIONS OF PRIVACY (keep out, go away, top secret, do not enter)	
Privacy Indicators	

APPENDIX E

MODIFIED TEST OF SCIENCE RELATED ATTITUDES

NAME: ___________________________________

Modified Test of Science Related Attitudes (TOSRA)
(Adapted from: Fraser, 1981)

Directions:

1. This test contains a number of statements about science. You will be asked what you think about these statements. There are no “right” or “wrong” answers. Your opinion is what is wanted. **Your participation is completely voluntary.**
2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement.
3. **Please circle only ONE value per statement.**

5 = Strongly Agree (SA)
4 = Agree (A)
3 = Unsure (U)
2 = Disagree (D)
1 = Strongly Disagree (SD)

Statement	**SA**	**A**	**U**	**D**	**SD**
1. I would prefer to find out why something happens by doing an experiment than by being told.	5	4	3	2	1
2. Science lessons are fun.	5	4	3	2	1
3. I would like to belong to a science club.	5	4	3	2	1
4. When I leave school, I would like to work with people who make discoveries in science.	5	4	3	2	1
5. I would prefer to do experiments rather than to read about them.	5	4	3	2	1
6. School should have more science lessons each week.	5	4	3	2	1
7. I would like to be given a science book or a piece of science equipment as a present.	5	4	3	2	1
8. Working in a science laboratory would be interesting.	5	4	3	2	1
9. I would prefer to do my own experiments than to find out information from a teacher.	5	4	3	2	1
10. Science is one of the most interesting school subjects.	5	4	3	2	1
11. I would like to do science experiments at home.	5	4	3	2	1
12. I would like to teach science when I leave school.	5	4	3	2	1
13. I would rather solve a problem by doing an experiment than be told the answer.	5	4	3	2	1

Statement	SA	A	U	D	SD
14. I really enjoy going to science lessons.	5	4	3	2	1
15. A job as a scientist would be interesting.	5	4	3	2	1
16. I would prefer to do an experiment on a topic than to read about it in science magazines.	5	4	3	2	1
17. I look forward to science lessons.	5	4	3	2	1
18. I would enjoy visiting a science museum on the weekend.	5	4	3	2	1
19. I would like to be a scientist when I leave school.	5	4	3	2	1
20. If you met a scientist, he/she would probably look like anyone else you might meet.	5	4	3	2	1