A Three-Year Evaluation of the Polymer Science Project for Middle School

Dr. Jane Beese, Evaluator
Lucidations LLC
255 Woodhaven Dr.
Copley, OH 44321
330-310-0626

Dr. Carin Helfer, Program Director
Lucidations LLC
255 Woodhaven Dr.
Copley, OH 44321
330-310-0626

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Abstract

The Polymer Science Education for Middle School Project provides a model of curriculum and instruction for middle school students, which addresses the need for science career awareness embedded in standards-based science education. The federally funded project spanned a three-year period from 2008-2011. This project involved a learning community of pre-service and in-service science and math teachers; middle school students from a suburban middle school district; professional scientists and engineers; university science education professors, and parents. Project activities included teacher professional development, classroom instruction of science units, Polymer Family Night, Career Day, and a field trip to a university research laboratory. The purpose of this project and evaluation is to inform members of the science education community interested in interventions and to increase the pool of potential scientists and engineers from the middle school population to enter the higher education pipeline and the professional science community.

Introduction

Motivating American students to pursue careers in STEM (Science, Technology, Engineering, and Math) fields has been a focus of current reports, in particular the 2007 report to Congress *Rising Above the Gathering Storm* (Committee on Prospering in the Global Economy of the 21st Century, 2007). This report suggests the need for improvement in the quality of math and science education in schools in the U.S. Inadequate teaching of these subjects negatively impacts students' interest. In an earlier Congressional Report (Kuenzi, Matthews, & Mangan, 2006), the authors suggest that many teachers lack adequate subject matter knowledge, thus leading to an insufficient number of students prepared in STEM fields. Federal policy has renewed attention on the importance of STEM, both in the work place and in educational settings, as evidenced by the American Competitiveness Initiative and the analysis provided by the National Academy of Sciences report, *Rising Above the Gathering Storm* (Committee on Prospering in the Global Economy of the 21st Century, 2007).

Often students do not consider careers in the science or engineering fields because of their perception of scientists and engineers. Studies of students' images of scientists show that students believe that these careers are for men. (Schibeci, 1986). Research suggests that teaching behaviors, instructional strategies, and prolonged contact with professional scientists can change students' perceptions (Kahle, 1987; Alberts, 1994; Owens, 1998 & 1999). In order to inspire young people to embrace careers in science, teachers must help break the stereotypic image of scientists (Flick, 1990). Smith and Erbb (1986) suggest that teachers' use of resource persons in science careers could improve students' attitudes toward science. However, few teachers decide to incorporate career education for middle school students because of curriculum already crowded with required topics to teach, pressure of high-stake tests, and little information about science careers at their disposal; most teachers acknowledge its importance and prefer that it be taught in existing courses (Smith, 1982).

Teachers' knowledge needs to be enhanced and their curriculum adjusted to allow them to incorporate information about STEM careers into their science teaching. Teacher education is an imperative life-long process, following the continuum from teacher preparation through induction through experienced to master teacher. Continual updates both in content and in pedagogical tools are needed to enhance teachers' own learning and their students' achievement (Committee on Science and Mathematics Teacher Preparation, 2001).

The message to continue studies of math and science beyond elementary school needs to be communicated to the middle school students whose choices in high school may set the course for or against the pursuit of careers in the hard sciences or even those careers where science is less apparent. Elementary school students are often enthusiastic towards science and this enthusiasm drops by high school. Therefore, the critical years for intervention to maintain a positive interest in science are the middle grades (White & Richardson, 1993).

The Polymer Science Education for Middle School Project provides a model of curriculum and instruction for middle school students that addresses the need for STEM career awareness embedded in standards-based STEM education. The project involved a learning community of pre-service and in-service science, math, and special education teachers; middle school students; professional scientists and engineers; university science education professors; and parents. Project activities include teacher professional development, classroom instruction of polymer units, Polymer Family Night, Career Day, and a field trip to a university research laboratory.

Project Activities

Professional development (PD) activities included science teachers from the participating middle schools and pre-service science teachers. These teachers formed a learning community through participation in the PD activities and co-teaching activities throughout each academic year. There were two groups of pre-service teachers each year, one in the fall and a new group in the spring semester. The in-service teachers remained the same throughout each academic year. The PD activities took place during a one-day session at which participants experienced a unit of instruction focused on state standards (Physical Science, Scientific Inquiry, Scientific Ways of Knowing, and Science and Technology). Teachers were provided with lesson plans that could be modified to best fit their needs. Each of the lessons followed the learning cycle framework (Atkin & Karplus, 1962) and included underlying content knowledge, safety protocols, materials needed, alignment to standards, and multiple assessment suggestions.

Pre-service teachers were grouped and assigned to an in-service teacher to work with for the semester. This arrangement allowed pre-service teachers the ability to observe, prepare, co-teach, and assess their instruction of science lessons experienced in the PD sessions. Pre-service teachers noted, at the end of the project, that having a chance to meet and plan with in-service teachers on the Saturday PD day was the best part of the program. There were also PD discussions via postings in Springboard, face-to-face sessions during teachers' common planning time, and after school sessions.

Participating middle school students, their parents and siblings, pre-service and in-service teachers, university scientists and science education professors, district personnel, and interested community members attended Polymer Family Nights. In 2008-09, 134 people were in attendance, 236 people were in attendance in 2009-10, and 384 people were in attendance in 2010-11. During the family night, three stations with activities related to polymeric materials were set up for hands-on learning. Pre-service teachers led the activities at the stations. The participants were divided into three groups that rotated to each of the different stations. At each station, evaluation slips were present for the participants to provide feedback. These evaluation slips indicated a genuine interest in the activities offered at the Polymer Family Night. The participants stated that not only did they have fun, but they also learned about the characteristics of polymers.

Career Day took place during the regularly scheduled science class periods. Professional scientists and engineers described the dimensions of their careers, the rewards that can be derived, and how middle school students might prepare to pursue a career in science and math. Guests introduced themselves to the students by describing their childhood interests, education, and careers, often providing specific examples that helped students relate to the speakers. The importance of taking advanced math and science classes in high school was stressed to students. During one of the Career Day sessions, approximately 90% of students raised their hands when asked if they planned to go onto college.

The purpose of the field trip was to provide real-life experience in a campus setting. The following activities were included on the field trip: *Polymer Processing* that demonstrated film blow molding, injection molding, and extrusion, *Science Games* that used Wheel of Fortune for students to figure out scientific phrases, and *Polymer Rockets,* which allowed the students to build and test a rocket made of polymeric materials.

Research Questions

The Polymer Science Education for Middle School Project was a three-year, federally funded grant, which started in fall 2008 and ended in spring 2011. The purpose of the project was to inform members of the STEM education community interested in interventions and to increase the pool of potential scientists and engineers from the middle school population to enter the higher education pipeline and the professional science community. The focus of the evaluation was to identify the effects of PD on instructional practice, student/teacher perceptions of scientists, and teachers' awareness of science as a process. Additionally, the researchers sought to investigate how a learning community affected teacher growth. The following research questions guided the study:

1. How does participation in the project impact teachers' instructional practice?
2. How does participation in the project impact teachers' perceptions of scientists and engineers?
3. How does participation in the project impact students' perceptions of scientists and engineers?
4. How did the community of learning contribute to teacher growth?
5. What effect did the project have on students' pursuit in STEM based careers?

Participants

The participants in this study consisted of three years of pre-service teachers, in-service teachers and their middle school students; see Table A for breakdown by year. In years I and II, two grade levels participated in the study. The number of students that participated in year III is significantly less than years I and II because only a single grade level of students participated in year III. The project took place at two different school districts. For year I, the district was an urban, low-income district that was designated as needing improvement by the state's Department of Education. The school district for years II and III was a rural, low-income district that has been designated as continuous improvement by the state's Department of Education.

Table A: Participants by Year

Year	Pre-service Teachers	In-Service Teachers	Students
2008-09	24	11	481
2009-10	21	9	409
2010-11	25	4	204
Totals	**70**	**24**	**1094**

Methodology

A variety of data collection methods both quantitative and qualitative were employed that included student and teacher journal entries, teacher focus-group interviews, teacher and student *Draw a Scientist* assessments, classroom observations, the *Teacher Belief Instrument* (TBI), and student scores on the TOSRA. Statistical analysis was not possible, the first year, because all data was collected in aggregate, therefore, descriptive statistics were used to compare pre and post measures.

Teacher and Student Journals

Journal entries were used to assess teachers' instructional practice and approach to teaching science. Teachers answered questions pre and post participation in the project. Teachers were asked to write their answers to the following questions in their journals:

1. Describe instructional methods you use/would use to teach science/math?
2. What can teachers do in the science/mathematics classroom to motivate and engage students?
3. Describe your approach to teaching science/math? What steps would you use?
4. How well prepared are you to guide your students in careers in science/mathematics?
5. On a scale of 1 (low) to 5 (high), rate your knowledge on polymer science and polymer engineering. Please elaborate.
6. List or describe three goals that you have for participation in this program.

Students used their journals to record data from experiments and were asked to respond to the following questions:

1. What do you know about polymers? (pre)
2. What did you learn about polymers? (post)

Teacher Focus Group

Teachers were asked to describe changes that they have observed in their own practice as a result of program participation, explain how these changes came about, and discuss the effects of being involved in a community of practice. Specific discussion areas included:

- Impact on the quality of instruction
- Impact on understanding science-based careers and technology
- Impact on attitudes toward science and scientists

The focus group was held during the regularly scheduled class period for one hour. Questions were directly linked to project goals and were offered in order and exhausted before moving on to the next. Although each respondent did not necessarily respond to every question, several times during the session participants were prompted to "go around the table" and specifically respond to particular items. This methodology was employed so that conversation might be less stilted and so that items where greater variability might be expected could be fully answered.

Focus groups were digitally recorded so that specific quotes might be accessed for reporting purposes and one individual took detailed notes during the session. Following each session, responses were analyzed for commonality of answers and common themes of response.

Draw a Scientist Teacher and Students

The *Draw a Scientist* assessment was administered to both teachers and students to ascertain their image of scientists and any change over time on their perceptions after participation in the project. Participants made drawings of scientists, including physical characteristics, tools, setting, and descriptive words (Chambers, 1983). The scoring sheet was divided into upper and lower sections; with the upper section focused on symbols, technology, lab equipment, etc. and the lower section focused on alternative images such as gender, indications of secrecy, and mythic stereotypes. To test the reliability of the scoring process, four independent raters were used to establish inter-rater reliability. The sum was taken of the upper and lower scores resulting in the higher score being the most stereotypical. The drawings were made before any project activities were conducted and again at the end of each ten-week session.

Classroom Observations

Observations of teacher candidates and in-service teachers were conducted to determine the effect of the program and PD on teaching behaviors, instructional strategies. The external evaluator observed science/engineering problem-solving lessons in the classroom of participating teachers. Field notes were recorded and summarized.

TOSRA

Students' attitudes toward science, careers in science, and normality of scientists were measured using the *Test of Science-Related Attitudes* (TOSRA) (Fraser, 1978). Students took the TOSRA as a pre- and post-test. Data collected from this survey provided information regarding changes in students' attitudes over time.

Limitations

The data for this study were collected as part of the Polymer Science Education Middle School Project during academic years 2008-09, 2009-10, and 2010-11. The data collection was limited to a small group of pre- and in-service teachers. The low number of participants in this sample, for the first year, ruled out several statistical procedures as well as compromised statistical power. The sample was limited to three middle schools and was a much smaller representation of a much larger population. Data was collected in aggregate for the first two years; therefore, statistical analysis could not be conducted limiting the results of the study.

Findings

Teacher Journals

In the journals, teachers noted many instructional methods including small group activities, lecture, independent/group leading and discussion, direct instruction, guided inquiry, demonstration, hands-on approach, and the learning cycle. Most teachers noted that science instruction encompasses a variety of instructional methods but the methods they would use on a regular basis included direct instruction, demonstrations, discovery learning, and cooperative learning. Teachers felt direct instruction (lecture) was important for laying the foundation for what is to be learned. One teacher wrote, "Discovery learning or inquiry-based learning was important because real science is very hands-on and cannot simply be observed. I will be using instructional methods that incorporate inquiry-based learning with students seeking solutions to problems." According to teachers, demonstrations would be used for students to learn how to use equipment and learn the proper way to record data. Finally, teachers noted, "Science is about building upon the knowledge of others." Therefore, they would use cooperative learning so that "students will be given opportunities to work together, discover together, compare findings, and share knowledge." One teacher wrote, "Unlike other content areas, science is definitely a very hands-on subject, which means students will have to be allowed to participate in authentic situations, including performing experiments, making observations in the real world, and engaging with scientists from the real world." The "Learning Cycle" focuses on student driven exploration prior to elaboration and extension of the concepts presented. Teachers felt this method could easily include other methods such as discovery, inquiry-based learning, or problem solving. One teacher explained, "I will use the learning cycle, this will allow the students to interact and explore different activities which are explained in scientific thought. The different stages of the learning cycle beginning with the engagement encourage students to take control of their own learning by having them ask questions about what they expect to learn or want to know more about."

To engage and motivate students in the classroom, teachers felt it was necessary to "help students experience success, have some control over the lessons, and through discovery." One way to motivate and engage students is to keep the material from being dry. Explained by one teacher, "I want to relate what the students are doing to their personal lives and the world around them – e.g. what is important and relevant to them and their world? One way to do this is to find out what the students are passionate or inquisitive about and to use those passions/curiosities as a springboard when considering the individual lessons." Another teacher wrote, "Students can discover and make observations of their own instead of simply learning the way it is from a textbook. Application should always be a part of the lesson so the students know how the material relates to everyday life."

While teachers felt knowledgeable in the content areas of science and mathematics, they lacked extensive knowledge in the application of these fields. "My understanding only involves a basic generalization of the options available." Another teacher wrote, "I feel very prepared. Although, I know the importance of continuing education because science and technology are ever changing."

In reference to their knowledge on polymer engineering, most teachers scored themselves below 3. One teacher wrote, "2—I feel as though I now understand the very basics about polymers we were not taught about this subject in school, so I think I need more education to be comfortable with it." Another teacher commented, "1-I am clueless. When I learned that we would be teaching polymer lessons, I freaked. I know so little about the subject but I do know that polymers are everywhere!" Another teacher wrote, "I would rate myself a 3. I now know the basics and can differentiate the types of polymers and how some are made. I am aware of their application in everyday life. I don't know the depth of the content though."

Teachers indicated their goals for participation in the program. The goals included: "To gain a better understanding of various aspects of science, such as polymers which I currently lack in understanding. To be exposed to experienced professionals in my field. To gain insight and knowledge regarding possible careers involving science/mathematics. Provide engaging activities and lessons that will provide positive experiences for the students. Continue to develop teaching style." "To be better prepared to guide my students into careers involving science and mathematics, to gain science teaching experience, and to get students excited about science and careers they could pursue later in life."

The teacher journals were also to be used to capture materials handed out during PD training and schedules. However, most of the journals were empty of these materials. The bulk of information obtained from the journals was from the questions teachers were asked at the beginning of the project. Otherwise, there was very little information gleaned from the use of teacher journals.

Student Journals

Students were also given journals. A total of 890 journals were provided to the evaluator from middle school students during the first two years. The journals were used to record observations during experiments and to collect handouts. There were no evaluative marks or comments from the teacher. Therefore, the students never received feedback on the data they recorded on each experiment. The experiments in the eighth grade journals included a Gel Spike Experiment, Sports Helmets and Impact Testing, Mystery Powder, and the Balloon Ball Bounce. These experiments allowed the students to work as scientists and engineers would.

Table B is an example of a data table for the Sports Helmets and Impact Testing lesson taken from a student's journal. The data tables that were included in the journals were complete. Students made journal entries regarding what material they would use to design a helmet. This experiment is a very good example of real-world problem solving. The steps taken by the students during the experimentation model tests performed on plastic materials in industry. Therefore, the students are involved in the engineering design process, which requires them to think as engineers when selecting materials for a final product. A response obtained from a journal was, "I learned that acrylic breaks very easily. Black abs is a strong material." Another student wrote, "Drag racing it would have padding in it. It would have 5 layers of padding. The helmet would have a visor. The outside of it would be carbon fiber with a clear coat over it. It would have a strap." After the experiment this student wrote, "I want my helmet to be made of black abs. It seemed the strongest and did not break. I want my helmet to be made of black abs and the clpe because the black abs is hard for the outside and the clpe is soft and your helmet would be firm." Several students included their helmet design on colored paper. Another student wrote, "If you're going to wear a helmet don't make it out of acrylic materials. It will break and you'll get injured."

Table B: Data Table for Sports Helmets and Impact Testing

	Material Name/Observations	Material Name/Observations	Material Name/Observations
6 inches	Black abs Got little holes indents	Acrylic Very small dents	Polypropylene Pencil dent
12 inches	Bigger dents	Cracked into 4 pieces	Pencil dent
18 inches	Bigger dents		Marker dent
24 inches	Smaller dent deeper		Marker dent
30 inches	Smaller dents deeper		Sharpie dent
Bicycle helmet Black abs--strongest			

At the end of the program students were asked what they had learned. One student wrote, "I learned a lot of interesting stuff from these experiments. The experiments are fun and at the same time you learn about polymers and foam experiments." Therefore, the students were actually doing science or engineering in the manner that professionals would in their careers.

Teacher Focus Groups

The focus group promoted discussion of the project and the ways in which pre-teachers felt the program has affected 1) students understanding of scientists; 2) students understanding of science-based and technological careers; 3) the likelihood of students pursuing careers in the fields of science and technology; and 4) any change in attitude toward science. Teachers were encouraged to discuss how their own instructional practice changed since participating in the project, describe changes that they have observed in their own practice as a result of program participation, explain how these changes came about, and discuss the effects of being involved in a community of practice. The following results summarize the data as collected within the focus groups conducted for this project. The results are intended to provide a summary and analysis of strongly represented themes. Results will be discussed as they relate to each of the four areas of focus: impact on the quality of instruction, impact on understanding science-based careers and technology, impact on career choice, and impact on attitudes toward science and scientists.

Impact of Quality of Instruction: Many pre-service teachers suggested that this project did not change their approach in the science classroom or their teaching style. One participant said, “This is pretty much how I would teach anyway”. Another participant stated, “We are at the end of the program so I was going to teach the way I am going to teach”. This was supported by another comment, “We already know what to do going into it.” One pre-service teacher described his approach to the lessons as, “I kind of changed things to fit my own philosophy. I changed the bouncy ball lesson, cut some things out, and added information about polymers…added mass with the data”. While the pre-service teachers did not feel the program improved their instructional practice they did feel it would be beneficial if offered earlier in their coursework.

A difference was reported in the way the pre-service teachers felt about teacher preparation and student prior knowledge. Pre-service teachers realized the importance of planning and preparation for inquiry-based lessons and the need to be flexible in your approach. One pre-service teacher provided the example of his lesson being cut short because of a school assembly and having to adjust his approach on the fly. One pre-service teacher stated, “I had the lesson planned but once I got in there I realized it was going to take longer”. Another pre-service teacher felt it was crucial to plan questions. Another area of concern was student prior knowledge as stated by one participant, “I think it made us think about prior knowledge. We have to build on that. For example, there were a lot of students who didn’t know how to address an envelope and that took up a lot of teaching time …That’s basic information they should already know”. Understanding what students already know or do not know will help teachers better their lessons.

Impact on Understanding Science-based Careers and Technology: Pre-service teachers suggested that student knowledge of polymers and science-based careers was limited. One pre-service teacher stated, “I realize that here in Akron we come from the Rubber Capital of the World and these students don’t know anything about it”. Another pre-service teacher stated, “Kids are clueless on a lot of this”. Pre-service teachers felt the program did support student’s understanding of polymers and science-based careers. “I definitely feel the program helped. I had reflection questions at the end and asked if the program helped them understand science. Some of the students said it enhanced their understanding and some wanted to pursue careers in science”. Furthermore, another participant stated, “The students seemed engaged by the people who came in on career day. It was good for them to see the people who are actually scientists so they can relate to them. The woman who came in to talk to them made a difference with the girls”. Many participants felt the program, “definitely increased their learning” and was demonstrated by the “questions that were given to students at the beginning and then again at the end”. One participant said, "Most kids only knew one or two things about polymers in the beginning and at the end they knew five or six things".

Impacts on Students' Career Choices: All participants felt the program had a short-term impact on students' enjoyment of science and interest in pursuing science-based careers. A pre-service teacher stated, "Most thought science was boring and they found out science could be fun; when we were done with one lesson a student wanted to take home the activity to teach her little brother—it peaked their interest in science". Most pre-service teachers reported students being actively involved and engaged in science. For the short-term, pre-service teachers felt the program would increase students desire to pursue something science related with the majority of interest shown by the girls. "Everybody that asked me about jobs was all girls. They showed the most interest". Another pre-service teacher stated, "The most interesting questions I had were from the females. They were really interested in making the colors for the balls. There are scientists that spend all day making colors." Although pre-service teachers felt the program did impact students' interest in pursuing science-based careers, they felt it would not endure long-term as stated by one pre-service teacher, "In the long run, I don't think it will help because the program wasn't long enough". Another pre-service teachers said, "In high school they won't even remember it".

Impact on Attitudes Toward Science and Scientists: The opportunity for students to meet real scientists through field trips, Career Days, and Polymer Family Night was unanimously thought to have enhanced students' attitudes toward scientists and how they relate to science. Pre-service teachers felt taking this approach helped students look at science from different perspectives and helped students see scientists as "real people". The most important change pre-service teachers saw in their students was, "They want to do science. They were actively involved". One pre-service teacher recalled, "They even asked if we were coming back because they didn't want to start taking notes again". One pre-service teacher stated, "I think it depends on the teachers. If they get a whole bunch of hands-on lessons like this then I think it will definitely increase. Kids won't get bored. But if teachers go back to lecture and taking notes then no I don't think it will make a difference". Another stated, "Lecturing about it doesn't do the same as seeing it. That is a whole new world".

Community of Learning. Another component of the project was to create a community of learning. While everyone felt it was helpful to have the program as part of a class where pre-service teachers could support one another, the collegiality between pre-and in-service teachers was negligible. The collaboration and support between pre-service teachers was dependant on the teaching schedule. One pre-service teacher remarked, "I taught by myself. I didn't have anyone to fall back on. I did email the teacher what I was going to teach. I would come in 15 minutes before to see how she was teaching it and brought some of her ideas into my lesson". Other pre-service teachers noted how having a group of teachers working together was helpful, "I would go in early and talk to the people that taught before me and asked them what worked and what didn't". Most pre-service teachers felt the in-service teacher had little partnership. The following comments were made in reference to the relationship between pre-service and in-service teachers:

- “Our teacher left it completely up to us. She asked me at the beginning if we wanted to teach alone and we chose that. She didn’t have much impact. Chose to make our own, the teacher played little role”.
- “Really didn’t get any hands on with the teacher. Once we sat down she let it go. I didn’t gain anything from having her. She didn’t give me anything about the process. Just go in and wing it”.
- “It was frustrating because he had a plan period right before we came in and he didn’t talk to us”.
- ‘The teachers could have helped with prior knowledge on their days. They could have gone over that stuff. They didn’t even know what they were to do. They [students] didn’t even know how to do it. Check writing?”

To increase the impact of the program, participants suggested making the program longer. They felt the program was far too short to have a sustainable impact on students’ learning and attitudes about science. Another area for improvement was the actual lessons. One participant stated, “Some of the lessons weren’t the right length and all the class periods have different lengths. Some of the lessons needed to be connected to science careers but we didn’t have time. It needed to be a little longer to connect everything”.

TOSRA

The TOSRA is the Test of Science-Related Attitudes designed to measure seven distinct attitudes among middle school students. The test consists of seventy questions divided into seven scales. These scales are *Social Implications of Science, Normality of Scientists, Attitudes to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science*, and *Career Interest in Science*. Individual questions were added together and computed into new variables to establish the seven scales. The inventory was based on a five-point Likert Scale response format ranging from strongly disagree (1) to strongly agree (5). There were thirty-four negative items that were recoded from 5-4-3-2-1 to 1-2-3-4-5. The TOSRA was used to monitor student progress in science-related attitudes as a sample.

The TOSRA was administered as a pre and post assessment to a sample of 1094 middle school students: 481students in 2008-09, 409 students in 2009-10, and 204 students in 2010-11. Data was pre-screened before questions were recoded into the seven scales. A pattern of missing data was found in the pre-administration of the TOSRA. Consequently 72 data sets were removed. The mean was used to replace any other missing data.

Measures of variability were used to fully understand the distribution of the data. The measure of variability determined how the scores varied from the mean, see Table C. These categories display moderate to large standard deviations, which indicates that the average variability in a set of scores are further from the mean. Skewness and kurtosis indicate how the distribution varies from a normal (bell curve) distribution. All of the data is within the parameter of 1.2 for acceptable standards for skewness. Several categories displayed leptokurtic kurtosis, or a very peaked curve, indicating that the responses fell within the same area.

In 2008-09, changes in mean were noticeable in Social Implications of Science from the 29.22 to 34.19. All other scales pre and post means were within one point of each other. There is no way to determine statistical significance for year 2008-09 because the data was collected in aggregate. While we cannot determine statistical significance for any scales, we might assume the change in Social Implication of Science was significant due to the large increase in mean of 4.97 points.

Table C: Measures of Variability for TOSRA

Scale		Mean			Std. Deviation			Skewness			Kurtosis		
		2008-09	2009-10	2010-11	2008-09	2009-10	2010-11	2008-09	2009-10	2010-11	2008-09	2009-10	2010-11
Social Implications of Science	Pre	29.22	36.56	30.40	2.40	5.84	3.75	0.28	-0.03	0.60	3.11	0.11	1.48
	Post	34.19	36.58	30.91	5.02	7.13	3.59	-0.17	1.48	0.26	2.31	14.46	0.68
Normality of Scientists	Pre	32.28	33.66	30.38	4.08	4.59	4.18	0.60	-0.11	0.02	2.21	2.88	-0.07
	Post	33.84	35.70	31.76	4.40	6.25	3.99	0.52	-0.39	-0.08	2.07	0.13	0.17
Attitude to Scientific Inquiry	Pre	36.10	39.18	30.26	6.31	6.25	4.09	0.08	-0.39	0.48	-0.48	0.13	0.10
	Post	36.53	38.80	30.61	5.65	6.49	4.09	-0.07	-0.46	0.31	1.47	0.43	-0.21
Adoption of Scientific Attitudes	Pre	32.81	35.06	29.59	5.10	5.44	3.88	0.32	-0.37	0.17	0.34	0.83	-0.13
	Post	32.88	34.86	30.30	4.73	5.82	4.00	0.18	-0.08	0.31	1.70	0.03	0.12
Enjoyment of Science Lessons	Pre	31.04	38.52	28.81	6.69	7.87	3.46	0.06	-1.01	0.11	-0.14	1.23	0.36
	Post	30.57	37.52	29.49	6.16	8.23	3.05	-0.29	0.26	0.09	0.66	-0.47	-0.29
Leisure Interest in Science	Pre	26.81	28.20	32.16	7.15	8.82	4.33	0.07	0.26	0.01	-0.24	-0.47	-0.06
	Post	25.91	27.86	32.17	6.75	8.72	4.51	0.60	0.15	-0.33	2.71	-0.24	-0.13
Career Interest in Science	Pre	28.18	32.22	29.11	6.81	8.29	3.14	0.15	-0.09	-0.09	0.47	-0.29	1.17
	Post	28.85	32.27	29.87	5.73	8.04	3.15	-0.18	-0.16	-0.33	2.00	0.28	0.11

In 2009-10 and 2010-11, paired sample t-tests for dependent means were used to calculate the difference between the means for pre-test and post-test scores for each scale. For 2009-10, comparison of pre and post-scores in Normality of Scientists revealed $t_{(349)} = 7.877$, $p < 0.000$ which is statistically significant. The mean of pre-test scores was 33.66 and the mean of post-test scores was 35.70. The difference between the means of the pre-test and post-test groups is 2.04. Comparison of pre and post scores in Enjoyment of Science Lessons revealed $t_{(349)} = 2.791$, $p < 0.006$ which is statistically significant. The mean of pre-test scores was 38.52 and the mean of post-test scores was 37.52. The difference between these means is 1.00.

For 2010-11, comparison of pre and post-scores in Normality of Scientists revealed $t_{(180)} = 7.092$, $p < 0.000$ which is statistically significant. The mean of pre-test scores was 30.38 and the mean of post-test scores was 31.76. The difference between the means of the pre-test and post-test scores is 1.38. Comparison of pre and post-scores in Adoption of Scientific Attitudes revealed $t_{(180)} = 2.178$, $p < 0.031$ which is statistically significant. The mean of pre-test scores was 29.59 and the mean of post-test scores was 30.30. The difference between the means of the pre-test and post-test scores is 0.72. Comparison of pre and post-scores in Enjoyment of Science Lessons revealed t $_{(180)}$ = 2.279, $p < 0.024$ which is statistically significant. The mean of pre-test scores was 28.81 and the mean of post-test scores was 29.49. The difference between the mean of the pre-test and post-test scores is 0.67. Comparison of pre and post-scores in Career Interest in Science revealed t $_{(180)}$ = 2.832, $p < 0.005$ which is statistically significant. The mean of pre-test scores was 29.11 and the mean of post-test scores was 29.87. The difference between the means of the pre-test and post-test scores is 0.76.

Next, the effect size was calculated for the scales that were statistically significant. For 2009-10, Normality of Scientists, the es = -0.18 and Enjoyment of Science Lessons the es = 0.06, which indicate a small to negligible effect. For 2010-11, Normality of Scientists the es = 0.08, Adoption of Scientific Attitudes the es = 0.09, Enjoyment of Science Lessons the es = 0.10, Career Interest in Science the es = 0.12, which indicates a small to negligible effect. See Table D for effect sizes.

Table D: Effect Size for TOSRA scales

Scale	Effect Size	
	2009-10	**2010-11**
Normality of Scientists	-0.18	0.08
Adoption of Scientific Attitudes	--	0.09
Enjoyment of Science Lessons	0.06	0.10
Career Interest in Science	--	0.12

N = 409 (2009-10); N = 204 (2010-11)

Comparison and analysis of the pre and post-scores of the TOSRA show that participation in the project had a small effect on students' science related attitudes. Findings show that participation had a small effect on students' view of scientists in academic year 2009-10. In 2010-11, the areas of impact included four scales: Normality of Scientists, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, and Career Interest in Science. The increase in the Normality of Scientists scale may indicate an increase in favorable attitudes towards science and scientists, seeing scientists as normal people rather than stereotypical figures. The increase in the Adoption of Scientific Attitudes scale may indicate an openness or willingness to modify their attitudes and opinions. The increase in the Enjoyment of Science Lessons scale may indicate an enjoyment in science learning experiences. Finally, an increase in the Career Interest in Science scale may indicate the development of interest in pursuing a career in a scientific field. In general, it appears that participation increased students' enjoyment of science and provided experiences that changed their attitudes and perspectives of science and scientists. The small effect sizes may be indicative of the timeframe of the program. Influencing changes in science related attitudes might require a longer period of time.

Draw A Scientist Teachers

Pre and post-drawings were provided by 70 pre-service teachers and 24 in-service teachers. Analysis of the teacher drawings assessment demonstrated a change in stereotypic views. In 2008-09, the pre-participation mean was 6.11 and the post-participation mean was 4.0. In 2009-10, the pre-participation mean was 5.53 and the post-participation mean was 3.31. In 2010-11, the pre-participation mean was 4.73 and the post-participation mean was 4.39. This indicates a general reduction in stereotypical views. From review of descriptive data, there is a definitive reduction in stereotypical views of scientists, with scores being more similar for post-drawings than for pre-drawings.

An illustrated example of the range of drawings is shown in Figure 1. These show pre and post high scoring and low scoring teacher examples. Low scoring examples might have one or two stereotypes of scientists in them (e.g., male and Caucasian), but the example below is less stereotypical in that it shows a woman, the scientist works outdoors, there are no lab coats, and there are minimal if any symbols of research. The high scoring example shows stereotypical things like lab equipment, eyeglasses, lab coats, symbols of knowledge (pockets), and captions. In this example, the scientist is a Caucasian male. This illustration depicts a stereotypic image of a scientist, specifically a chemist. Note the lab coat, pocket protector, facial hair and acne, glasses, and lab equipment. Not only does the teacher draw a stereotypic image of a scientist right down to the planet themed tie but they also include dialogue bubbles stating, "After years, I have finally done it! A HA HA HA and $E=MC^2$."

Scoring of the drawing was based on specific aspects or characteristics of the stereotypical view of scientists. The frequency of characteristics changed in pre and post-drawings, as shown in Table E. In 2008-09, fewer teachers drew scientists as male gendered, Caucasian, or middle-aged/elderly and there were fewer indications of danger. There was a noted increase in eyeglasses, facial hair, symbols of research, symbols of knowledge, light bulbs, mythic stereotypes, and indications of secrecy. In 2009-10, fewer teachers drew scientists with lab coats, eyeglasses, or facial hair. There was also a reduction in symbols of research and symbols of knowledge, technology, male gender, indications of danger, light bulbs, mythic stereotypes, indications of secrecy, and scientists working indoors. In 2010-11, fewer teachers drew scientists with lab coats, eyeglasses, symbols of research, symbols of knowledge, and who were middle-aged or elderly. Teachers' drawings depicted fewer mythic stereotyped images and scientists who worked indoors. There was an increase in technology, captions, danger, light bulbs, and scientists who were male or Caucasian. Overall, there definite change in race and ethnicity was noted, with fewer scientists being drawn as Caucasian.

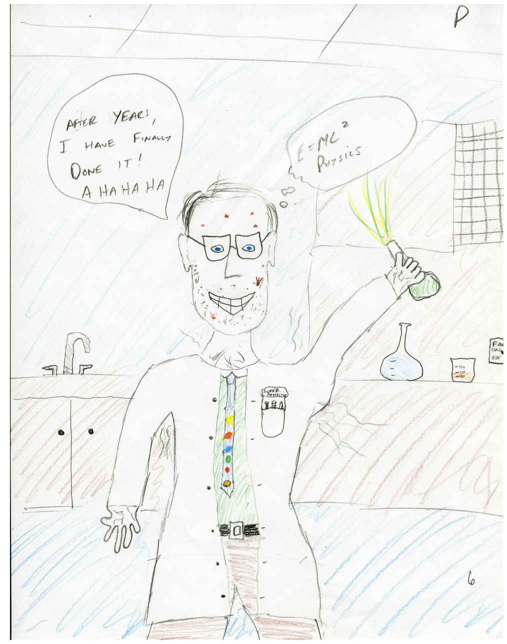

Figure 1.1 Teacher Rendition of Draw a Scientist

Figure 1.2 Teacher Rendition of Draw a Scientist

Table E. Frequency of Teacher Stereotypical Characteristics of Scientists

Characteristics	2008-09		2009-10		2010-11	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Lab Coat	33.3	31.3	43.3	18.8	46.7	27.8
Eyeglasses	18.1	25.0	66.7	0.0	26.7	11.1
Facial Hair	9.0	25.0	10.0	0.0	0.0	0.0
Symbols of Research	9.0	87.5	86.7	62.5	80.0	66.7
Symbols of Knowledge	9.0	18.8	33.3	25.0	50.0	50.0
Technology	0.0	0.0	13.3	0.0	0.0	22.2
Male Gender	45.5	31.3	40.0	31.3	76.7	88.9
Caucasian	81.1	12.5	86.7	81.3	26.7	27.8
Indication of Danger	9.0	0.0	23.3	0.0	93.3	94.4
Light Bulbs	0.0	6.3	6.7	0.0	10.0	11.1
Mythic Stereotypes	0.0	6.3	3.3	0.0	0.0	5.6
Indication of Secrecy	0.0	6.3	0.0	0.0	3.3	0.0
Working Indoors	27.3	25.0	50.0	18.8	0.0	0.0
Middle or Elderly/Aged	18.2	12.5	10.0	0.0	60.0	44.4

N = 25 (2008-09); N = 20 (2009-10); N = 29 (2010-11)

For Year I, the post-drawings contained a greater variety of types of scientists, see Table F. The pre-drawings only referenced astronomers, biologists, and chemists. In addition to these, the post-drawings referenced botanists, medical scientists, physicists, and science teachers. Years II and III, when compared to the pre-drawings, the post-drawings contained fewer types of scientists. The pre-drawings depicted chemists (43.3%), biologists (10%), paleontologists (3.3%), astronomer (3.3%), *anyone* as noted in the caption that anyone can be a scientist, (13.3%), multiple scientists (20%), and unknown (6.7%). The post-drawings consisted of chemists (38.9%), biologists (5.6%), anyone (27.8%), and multiple scientists (22.2%). The largest percentage of drawings pre and post were chemists. Post-drawings contained a much higher number of drawings with multiple types of scientists or that described anyone as being a scientist. The idea that science is all around us and that anyone can be a scientist was a theme throughout the program that was evidenced in the drawings.

Table F: Percentage of Types of Scientists (Teachers)

Types of Scientist	2008-09		2009-10		2010-11	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Astronomer	25.0	12.5	--	--	3.3	--
Biologist	8.3	6.3	--	--	10.0	5.6
Botanist	--	6.3	--	--	--	--
Chemist	50.0	50.0	68.8	56.0	43.3	38.9
Medical	--	6.3	--	--	--	--
Physicist	--	6.3	--	--	--	--
Science Teacher	--	6.3	--	4.0	--	--
Paleontologist	--	--	--	3.3	--	--
No Indication	--	--	18.8	40.0	10.0	27.8
Multiple	--	--	--	--	20.0	22.2

N = 25 (2008-09); N = 20 (2009-10); N = 29 (2010-11)

Paired sample t-tests for dependent means were used to calculate the difference between the means for pre-drawing and post-drawing total scores for years II and III. In Year II, comparison of pre and post total scores revealed $t_{(349)} = 2.626$, $p < 0.019$ which is statistically significant. The mean of pre-test scores was 5.53 and the mean of post-test scores was 3.31. The difference between the means of the pre-test and post-test groups is -2.22. The es = 0.62 which is a large effect.

In 2010-11, paired sample t-tests for dependent means were used to calculate the difference between the means for pre-drawing and post-drawing total scores. For those that did not have post data, the group mean for post was inserted for analysis. Comparison of pre and post total scores revealed $t_{(29)} = 0.90$, $p = 0.38$, which is not statistically significant. The mean of pre-test scores was 4.73 and the mean of post-test scores was 4.39. The difference between the means of the pre-test and post-test groups is -0.34. This indicates that there was not a significant change in scientist illustrations for teachers from pre to post. A potential reason for this might be illustrated by a caption one teacher wrote: “I still believe in my first drawing – I’ve simply added another tool to my teaching tool belt.” Additionally, teachers did start with relatively low scores, considering scores can range from 0 to 15 on this measure. It is also possible that the missing data made it harder to identify any changes, since 40% of the teachers’ data had to be replaced with the mean.

Draw A Scientist Students

Drawings were collected at the beginning and end of the program from 1094 middle school students. For 2008-09, drawings were collected without names or coding. Therefore, data was analyzed in aggregate. In 2009-10 and 2010-11, the drawings were collected without names but were coded to identify pre versus post-drawings. The pre-drawings were compared to the post-drawings to determine if there was a change in students' view of scientists.

Figure 2.1 Student Rendition of Scientist– Low-scoring (Pre)

Figure 2.2 Student Rendition of Scientist – High-scoring (Pre)

Figures 2.1, 2.2, and 2.3 are pre-drawings. The example shown in Figure 2.1 shows a non-stereotypic image of a scientist. Note the caption "Anyone—Science" indicating that anyone at any age (ages on shirts) can be a scientist. There is also a lack of danger, mythic stereotypes, lab coats, science equipment, etc. Contrasting this image is Figure 2.2. This illustration depicts a stereotypic image of a scientist, specifically a chemist. Note the lab equipment, the liquids in the beakers boiling with heat emanating from them, and the scientific charts on the walls, as well as the Frankenstein-like creature on the bottom. Finally, Figure 2.3 depicts a scientist of mid-scoring range. Figure 2.3 is a picture of a paleontologist in a museum describing the fossils of a Tyrannosaurus Rex to a student. Although the scientist is wearing a lab coat, there is no danger, no lab equipment, and the scientist is not Caucasian.

Figures 2.4 and 2.5 show post-drawing examples. Figure 2.4 is low scoring and is similar to the pre-drawing that scored low – it shows a female, young scientist with no lab equipment. She is not wearing a lab coat. Figure 2.5, however, is somewhat different from the high-scoring pre-drawing. This one shows many stereotypes including aspects of danger, a lab coat, and a Caucasian male scientist, but does not have the Frankenstein-like creature or the scientific charts present in the pre-drawing.

Figure 2.3 Student Rendition of Scientist – Mid-scoring (Pre)

Figure 2.4 Student Rendition of Scientist – Low-scoring (Post)

Figure 2.5 Student Rendition of Scientist – High-scoring (Post)

Analysis of the drawings assessment demonstrated a change in stereotypic views. In 2008-09, the pre-participation mean was 5.28 and the post-participation mean was 4.69. In 2009-10, the pre-participation mean was 3.81and the post-participation mean was 4.05. In 2010-11, the pre-participation mean was 5.42 and the post-participation mean was 4.99. There was a decrease in stereotypical views of participants, and the views at post were more similar. A closer look at the categories that demonstrated an increase may provide a more telling account.

Table G. Frequency of Student Stereotypical Characteristics of Scientists

Characteristics	2008-09		2009-10		2010-11	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Lab Coat	75.3	40.7	23.7	14.5	47.6	33.3
Eyeglasses	56.0	37.8	19.8	10.0	16.9	21.4
Facial Hair	15.3	9.5	6.3	44.5	6.3	4.8
Symbols of Research	52.0	80.7	82.0	45.5	84.1	80.4
Symbols of Knowledge	52.0	17.9	14.8	9.2	33.3	17.9
Relevant Captions	16.7	14.7	9.2	30.9	8.0	15.5
Technology	10.7	10.2	59.1	53.0	41.3	35.7
Male Gender	79.3	60.4	84.7	47.4	60.0	63.1
Caucasian	99.3	89.1	11.9	2.9	93.7	93.4
Indication of Danger	8.0	15.1	5.0	3.4	34.4	20.8
Light Bulbs	2.0	1.8	6.3	0.3	9	4.2
Mythic Stereotypes	2.0	8.1	0.3	12.4	13.8	11.3
Indication of Secrecy	0.0	3.2	40.4	9.7	2.6	3.0
Working Indoors	58.0	70.9	2.4	2.9	87.3	93.5
Middle or Elderly/Aged	1.3	6.3	23.7	14.5	6.9	0.6

N = 481 (2008-09); N = 409 (2009-10); N = 204 (2010-11)

The frequency of characteristics changed in pre and post-drawings. In 2008-09, the following characteristics demonstrated a decrease: lab coats, eyeglasses, facial hair, symbols of knowledge (books, filing cabinets, clipboards, pens in pockets, etc.), relevant captions, male gender, and Caucasian aspects. In 2009-10, the following characteristics demonstrated a decrease: lab coats, eyeglasses, symbols of research, symbols of knowledge (books, filing cabinets, clipboards, pens in pockets, etc.), male gender, Caucasian, indications of danger, light bulbs, mythic stereotypes, and working indoors. The characteristics that demonstrated an increase include facial hair, technology, and indication of secrecy. In 2010-11, the following characteristics demonstrated a decrease: lab coats, facial hair, symbols of research, symbols of knowledge (books, filing cabinets, clipboards, pens in pockets, etc.), captions, Caucasian, indications of danger, light bulbs, mythic stereotypes, and middle-aged or elderly. The characteristics that demonstrated an increase include eyeglasses, technology, male gender, working indoors, and indication of secrecy.

Post-drawings included a greater variety of types of scientists. This may account for the decline in lab coats and symbols of knowledge. It was noted that more students drew their scientists as female in the post drawings. This might explain the decrease in facial hair. Students' post-drawings displayed more ethnicities.

When compared to the pre Draw a Scientist drawings, the post-drawings contained more specific details and a greater variety of types of scientists, see Table H. Most students drew chemists at both pre and post, but many students also drew polymer scientists at post. They typically replicated an experience they had during the program. A number of drawings showed scientists using liquid nitrogen. Graduate students used liquid nitrogen to conduct experiments in front of the students during the field trip to the lab. Students also drew pictures of the polymer lab where graduate students demonstrated extrusion and injection molding. This may explain why scores on the drawings showed only a small decrease in stereotypical views, since some features they had presumably seen in their visit to the university and copied into their drawings were among the traits coded as stereotypical of scientists (e.g., working indoors). See Figure 2.6, which shows plastic molding, and figure 2.7, which shows a liquid nitrogen demonstration. Also, Figures 2.9, 2.10, and 2.11 show replication of experiences the students had in the program.

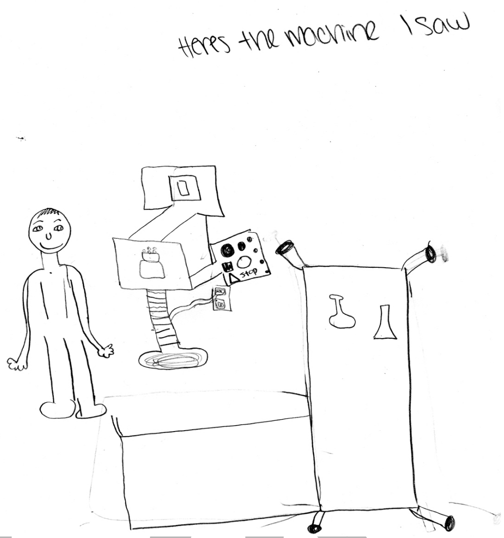

Figure 2.6 Drawing of Field Trip Experience in the Polymer Lab

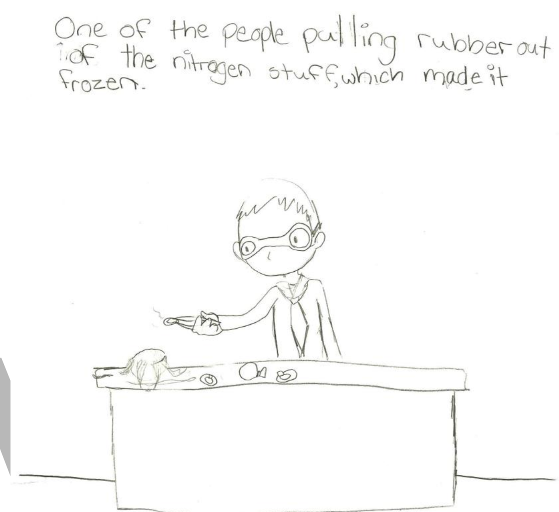

Figure 2.7 Drawing of Liquid Nitrogen Demonstration

The category, indications of danger, increased because of the number of students who included liquid nitrogen in their drawings, see figure 2.7 and 2.8.

Figure 2.8 Indications of Danger

Figure 2.9 Drawing of Liquid Nitrogen Demonstrations

Table H. Frequency of Types of Scientists by Students

Types of Scientist	2008-09		2009-10		2010-11	
	Pre	Post	Pre	Post	Pre	Post
Archeologist	--	--	3.1	1.1	2.1	--
Polymer Scientist	--	11.9	--	14.2	--	13.7
Astronomer	--	1.8	0.5	0.8	0.5	--
Biologist	0.9	1.8	3.1	3.6	8.4	3.9
Botanist	--	1.1	--	--	--	--
Chemist	29.2	68.4	35.6	38.5	68.3	60.7
Inventor	--	--	--	--	1.1	3.0
Medical	--	1.0	0.5	0.3	--	--
Engineer	--	--	0.5	1.4	--	--
Geologist	--	--	0.5	0.3	0.5	--
Paleontologist	--	--	--	--	1.1	--
Physicist	2.9	3.2	4.2	3.8	1.1	1.2
Science Teacher	2.9	3.9	0.5	1.9	0.5	1.8
Weapon Expert	--	--	1.0	0.6	--	--
Multiple	--	--	--	--	7.9	3.0
Unknown	60.8	4.6	44.0	33.0	7.4	5.9
Other	--0.5	4.7	--	--	0.5	4.2

N = 481 (2008-09); N = 409 (2009-10); N = 204 (2010-11)

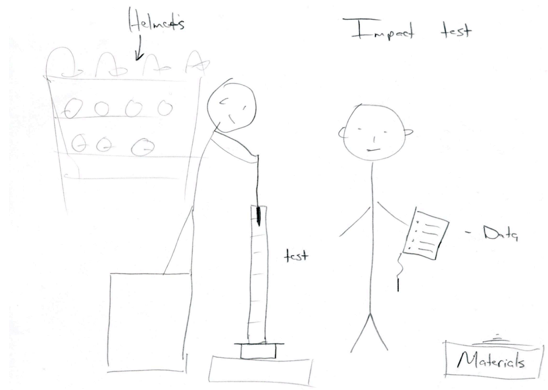

Figure 2.10 Drawing of Polymer Science Lab Demonstration seen during Field Trip

Figure 2.11 Drawing of Impact Testing Experiment with Helmet Materials

Paired sample t-tests for dependent means were used to calculate the difference between the means for pre-drawing and post-drawing total scores for years II and III. In 2009-10, comparison of pre and post-scores revealed $t_{(354)} = 2.065$, $p < 0.040$ which is statistically significant. The mean of pre-test scores was 3.81 and the mean of post-test scores was 4.05. The difference between the means of the pre-test and post-test groups is 0.24. The es = 0.06 which is a small to negligible effect. In 2010-11, comparison of pre and post-scores revealed $t_{(202)} = 2.89$, $p < 0.00$, which is statistically significant. The mean of pre-test scores was 5.42 and the mean of post-test scores was 4.99. The difference between the means of the pre-test and post-test groups is -0.43. The es = 0.13 which is a small effect. This indicates a small decrease in stereotypical ideas of scientists.

Site Observations

Site visits were conducted to observe teaching of both pre-service and in-service teachers who were project participants. The observations indicated that the students were excited to be part of the program and knowledgeable about the steps in the scientific method, and that the teachers were adept in the application of the program. Students were able to participate in the experiments and contribute to scientific discussions. For example, a teacher asked, “On the indentation would you want the lowest or the highest? If it goes lower it means it is forming to your foot more. So why did we do the elasticity and bounce test?” A student answered, “To see how much momentum it would give you as it leaves the ground.” The teacher responded, “Correct.” During both observations, it was noted that students understood polymer materials including cross-linking, characteristics, etc.

The program adopts a hands-on approach to learning the scientific process and implements different modes of learning, specifically auditory and tactile. Most of the time, directions and data sharing were given orally. The dependence on auditory learning was a hindrance to comprehension. At times, students required visual directions to comprehend the step-by-step process. There was also a lack of closure at the end of each lesson mostly due to time constraints. In fact, time management impacted the effectiveness of the scientific process because of the elimination of necessary introductory activities, rushing through directions, and failing to adequately debrief findings and conclusions.

Findings and Implications

TOSRA data indicated a small change in students' science related attitudes. The areas of impact included five scales: *Normality of Scientists, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Career Interest in Science* and *the Social Implications of Science*. The increase in the *Normality of Scientists* scale may indicate an increase in favorable attitudes towards science and scientists, seeing scientists as normal people rather than stereotypical figures. The increase in the *Adoption of Scientific Attitudes* scale may indicate an openness or willingness to modify their attitudes and opinions. The increase in the *Enjoyment of Science Lessons* scale may indicate an enjoyment in science learning experiences. An increase in the *Career Interest in Science* scale may indicate the development of interest in pursuing a career in a scientific field. Finally, an increase in the *Social Implications of Science* may indicate an awareness that science can contribute to society. In general, it appears that participation in the program increased students' enjoyment of science and provided experiences that changed their attitudes and perspectives of science and scientists. The small effect sizes may be indicative of the timeframe of the program. Influencing changes in science related attitudes might require a longer period of time. However, these changes in science related attitudes were evident during program events, site observations, and in student drawings.

The opportunity for students to meet real scientists through field trips, career days, and polymer family night positively affected students' attitudes toward scientists and related to science. Pre-service teachers felt this approach helped students to look at science from different perspectives and helped students see scientists as "real people." The most important change participants saw in their students was, "They want to do science. They were actively involved." The field trip provided students with real-life experience in an on campus setting. Students were escorted through several processing laboratories where researchers explained and demonstrated products and processes under investigation. The graduate students who explained polymer processing in the plant did an excellent job of relating what was happening in the laboratories to their own experiences. One graduate student explained, "The materials we use are called polycarbonates. Your glasses are actually polycarbonate. You know that smell in Halloween masks? That's Santoprene. It's rubber but it's not like tires—tires you can't injection mold because the material will gunk up the machine." The pre-service teachers were able to question the students so they could draw conclusions about what was happening scientifically. During the liquid nitrogen demonstration the graduate student stated, "We can take rubbery items and cool them down so that the molecules get closer together and the items get hard—as they heat up they get rubbery again. What would that property be like?" The student said, "Tires." The graduate student responded, "Yes, you would not want tires to be too glassy but to warm up and get rubbery again. When you make things glassy, what are those properties good for?" Students responded, "Recycling so things can break down." "Yes, you can make it really cold and smash it down." Because graduate students connected the demonstrations to what the students learned in the classroom and talked to students in a manner that was interesting and at their level, students understanding of polymers was enhanced. One pre-service teacher mentioned, "When we were on the campus tour, the students were applying their knowledge of polymers to the campus." They asked, "Wow is that sculpture made of polymers?" "There was this split rock with rubber running through it and they were noticing these things and trying to figure it out. On a fun day, they took science out of the classroom. The field trip pulled it all together."

Career Day brought scientists into the classroom to talk to students about their professions. Heidi Cressman was introduced to students as a mechanical engineer. She discussed the 14 challenges society is faced with today that can be solved by science. Students were very interested in the challenges because they were issues familiar to them and relevant. Some of the challenges included sustainability, health, joy of living, and vulnerability. She also discussed different types of scientists and characteristics of engineers. This discussion led to college and career readiness. She asked, "When you graduate high school you will be competing with a lot of students your age. What are you going to do when it comes time to apply to college; what will you do to stand out? You need to do well in math and science". She discussed what students could do now to prepare. She said, "Ask questions. Take the highest classes now. Go to science camps. When you get into high school take calculus, physics, chemistry, and biology. Take advanced placement courses. Take the ACT and SAT and if you score low retake them". Students were very attentive during the class period and contributed to the discussion. One of the goals of the project is to take kids that may not be thinking of college and change their thinking so that college is a part of their thinking.

Another event that was part of the program was Polymer Family Night. There were three stations set up for students and their families to participate in science related activities. Evaluation slip responses indicated a genuine interest in the activities offered at the Polymer Family Night event and that participants not only had fun but also learned about the state and characteristics of polymers. Every child won a door prize. Parents expressed their enthusiasm for the event with many "thanks" at the close of the event. The Polymer Family Night was important because, "It influenced them and hit home and brought in support from their families." I believe the community has to be part of your teaching if you are going to be successful."

Students' knowledge of polymers increased after participation in the project. Teachers reported that the project provided opportunities to students, some that they would not have had normally. Students were able to participate in the experiments and contribute to scientific discussions. During both observations, it was noted that students understood polymer materials including cross-linking, characteristics, etc. Pre-service teachers felt the program did support students' understanding of polymers and science-based careers. One teacher stated, "It had a very positive impact on the students and on me. I did more science in two months than I did the entire time I was in school."

The program had a positive impact on students' enjoyment of science and interest in pursuing science-based careers. Teachers reported that students were more aware of careers in science and what they would be able to do if they pursued a career in science. One teacher stated, "We gave them the opportunity to look at careers. We did the shoe experiment and tied in business and marketing." One team had issued exit tickets to students and asked how many would pursue a career in science. The result indicated that 72% wanted to pursue a career in science and 56% of the class wanted to work in polymer science. One pre-service teacher stated, "We really showed them that you don't have to be a millionaire—almost anyone can go to school and major in polymers." Finally, one pre-service teacher provided a classroom example, "It increased the students' involvement. I asked who wanted to touch something gross and every single kid wanted to touch it—everyone was involved in the lesson." Several teachers voiced their concerns about the impact on students' career choices. "I don't think we transformed anyone's career plans. We were simply an interruption in their normal day."

These activities broadened and inspired students. Participants felt taking this approach helped students look at science from different perspectives and helped students see scientists as "real people." The most important change participants saw in their students was, "They want to do science. They were actively involved." One pre-service teacher stated, "This project made science authentic—it brought a real life aspect to the classroom that engaged students in real meaningful learning." A classroom teacher supported this sentiment by writing, "They LOVE science - they are excited to come to class, and don't complain about the work (as much!)."

Draw a Scientist was administered to students and collected pre and post treatment to measure the degree of stereotypical views of scientists and science related careers. The pre-participation mean was 5.28 and the post-participation mean was 4.69 with a loss of -0.59 (year 1). The mean of pre-test scores was 3.81 and the mean of post-test scores was 4.05 with a net gain of 0.24 (year 2). The mean of pre-test scores was 5.42 and the mean of post-test scores was 4.99 with a loss of -0.43 (year 3). Comparison of pre and post-scores were conducted for years 2 and 3 because data was coded for analysis. Year 2 revealed $t_{(354)} = 02.065$, $p < 0.040$ which is statistically significant. The es = 0.06 which is a small effect. Year 3 revealed $t_{(202)} = 2.89$, $p < 0.00$, which is statistically significant. The es = 0.13 which is a small effect. This indicates a small decrease in stereotypical ideas of scientists. The frequency of characteristics changed in pre and post-drawings. The following characteristics demonstrated a decrease: lab coats, facial hair, symbols of research, symbols of knowledge (books, filing cabinets, clipboards, pens in pockets, etc.), captions, Caucasian, indications of danger, light bulbs, mythic stereotypes, and middle-aged or elderly. The characteristics that demonstrated an increase include eyeglasses, technology, male gender, working indoors, and indication of secrecy. Post drawings contained more specific details and a greater variety of types of scientists. Most students drew chemists both pre and post, but many students also drew polymer scientists at post. They typically replicated an experience they had during the program. A number of drawings showed scientists using liquid nitrogen. Graduate students used liquid nitrogen to conduct experiments in front of the students during the field trip to The University of Akron. Students also drew pictures of the polymer lab where graduate students demonstrated extrusion and the process of molding. This may explain why scores on the drawings showed only a small decrease in stereotypical views, since some features they had presumably seen in their visit to the university and copied into their drawings were among the traits coded as stereotypical of scientists (e.g., working indoors).

Draw a Scientist was administered to teachers and collected pre and post treatment to measure the degree of stereotypical views of scientists and science related careers. Data was coded for years 2 and 3. Year 2 analysis of teacher Draw a Scientist illustrations demonstrated a decrease in stereotypical views. The pre-participation mean was 5.53 and the post-participation mean was 3.31. This indicates a general reduction in stereotypical views with a net loss of -2.22. A paired sample t-test for dependent means was used to calculate the difference between the means for pre-drawing and post-drawing total scores. Comparison of pre and post total scores revealed $t_{(349)} = 2.626$, $p < 0.019$ which is statistically significant. The es = 0.62 which is a large effect. Year 3 analysis indicates no change in stereotypical views. The mean of pre-test scores was 4.73 and the mean of post-test scores was 4.39. The difference between the means of the pre-test and post-test groups is -0.34. Comparison of pre and post total scores revealed $t_{(29)} = 0.90$, $p = 0.38$, which is not statistically significant. This indicates that there was not a significant change in scientist illustrations for teachers from pre to post. A potential reason for this might be illustrated by a caption one teacher wrote, “I still believe in my first drawing – I’ve simply added another tool to my teaching tool belt.” Additionally, teachers did start with relatively low scores, considering scores can range from 0 to 15 on this measure. Another contributing factor was that in-service teachers were in there second year of the project.

Teachers’ use of inquiry-based methods of teaching science and use of problem solving in their instructional practices was noted in the teacher journals. Early journal entries included instructional methods such as direct instruction, guided inquiry, demonstration, hands-on approach, and the learning cycle. Teachers indicated that a variety of instructional methods was necessary to engage the learner. Many teachers felt the use of a variety of instructional methods was necessary to engage the learner. One teacher stated, “I think presentation teaching followed by small group work is the way I would teach a science class. I feel students learn better when they are doing hands-on activities in a science classroom.” To engage and motivate students in the classroom, teachers felt it was necessary to “show students how what they are learning relates to their own personal lives.” Teachers also need to engage their students and make them active participants in their learning.

Another component of the program was to create a community of learning. Substantial changes were made to improve the relationships between pre-service teachers and the in-service teachers, who were the mentors. Pre-service teachers were put together in groups of four. These groups were used to team teach lessons. Each lesson was designed to support a lead teacher with three additional teacher candidates to support the lesson. Group planning and collaboration helped develop a community of learners.

The instructor took steps to facilitate a community of learning. The first attempt was a Google Groups site to bring the in-service teachers, pre-service teachers, and university personnel together (virtually) when planning and implementing lessons. The site was password protected, required an account and in the end was far too cumbersome. People found it time consuming and stopped trying. The ‘want’ to use it was there but it was the wrong technology. Another effort involved putting students together in groups of four to team teach at the same time in the same classroom. Each lesson had a lead teacher with three others to help facilitate the lesson. The group planning and collaboration really helped to develop a community of learners. Students felt more comfortable in their teaching, felt in control of their lesson, and really pushed themselves to try things they would not have done alone, such as tie dye t-shirts for all 204 6th graders. All candidates said that having a chance to meet and plan with teachers on the Saturday PD day was the best thing about this program.

It is highly suggested that PD be provided to pre-service teachers and in-service teachers on reflective journaling prior to beginning the project. For three years, the data gleaned from teacher and student journals has been minimal and efforts could be better directed had teachers been provided with training before the initial polymer lessons with the students. The questions should reflect student achievement and students' perceptions of scientists. An alternative would be to forgo the teacher/student journal and collect data by means of a focus group or student interviews.

Possible implications of this project would be to implement components of the project into science classrooms in general and to lengthen the program to have a more sustainable impact on student learning and perceptions. The development of a learning community is an area of strength in year III of the project and served as the foundation for pre-service teacher professional growth. Other programs to foster better pre-service teacher/mentor relationships could implement some of the ideas that were used in this project such as team teaching, fieldwork, etc.

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