Scientists' Classroom Visits and Middle School Students' Interests in Science Careers

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Abstract

The purpose of this descriptive study was to determine the effect of scientists' classroom visits on students' science career interests in rural Texas middle schools. Scientists from the Partnership for Environmental Education and Rural Health (PEER) program visited 1643 students in 29 rural Texas public schools. PEER scientists presented environmental health science topics that were integrated into regularly scheduled science, mathematics, English, language arts, and social studies lessons. Students' interests in science careers were positive after scientists' classroom visits. Students perceived parents or guardians, teachers, other family members, and friends as influential information sources affecting their interests in science careers. Fifth grade students had significantly more positive interests in science careers than did students in all other grades. A targeted effort is needed to incorporate more scientists' visits in sixth and seventh grade classes to counter students' waning interests in science careers during those years.

Introduction

As most students advance through middle school science classes, their attitudes toward science become more negative and their interests decrease most in the seventh grade (Cavallo and Laubach, 2001; Cohen-Scali, 2003; Gibson and Chase, 2002; Ma and Wilkins, 2002). Females, minorities, students from single-parent homes, and students living in poor socioeconomic conditions generally have more negative perceptions of science than do males, Caucasians, students from two-parent families, and students of high socioeconomic status (Barman, 1999; Blosser, 1990; Ma and Ma, 2004; Ma and Wilkins, 2002). Evidence suggests that students who have positive relationships with teachers, parents, and peers have positive attitudes toward science (George, 2000). These trends may signal threats of stagnation in the science industry. We could speculate that for our scientific community to remain competitive worldwide, it must have depth and versatility, which could be achieved through a workforce that is representative of our society.

Middle school is an intense time in a child's life. Adolescents mature at a very rapid pace, both physically and mentally. Cohen-Scali (2003) found that middle school children (at age 13) begin to assess professions and careers and form ideas based on the information they have absorbed throughout their childhood. In a study concerning science achievement of middle and high school students, Gibson and Chase (2002) reported that middle school students excelled in science at a much faster rate than did high school students. Ma and Wilkens (2002) concluded there is decreasing interest in science as students move from middle to high school, most notably during the seventh grade. While many reasons may contribute to students' waning interests in science careers during seventh grade, one of those reasons may be due to the lack of practical examples of scientists, their work, profession, and relative importance to our society.

Research shows that middle school students who maintained positive attitudes toward academics were significantly influenced by their parents/guardians, teachers, other family members, and peers; however, it was teachers who most influenced students' attitudes toward science (Fredriksen and Rhodes, 2004; George, 2000; Gibson and Chase, 2002; Harris and Alexander, 1998; Kerka, 2000; Lindner et al., 2004; Ma and Ma, 2004; Ma and Wilkins, 2002; Xu, 2004). According to George (2000), students thought teachers had the greatest ability to pique their interests in science careers at school, but outside of school, parents motivated students' curiosity about science careers.

A study by Lindner et al. (2004) found that most middle school (grades 6 to 8) students considered their parents or guardians as the most influential sources affecting their interests in science careers, with teachers being the second most influential sources. Students, who deemed their teachers (over parents and guardians) as influencing their interests in science careers more than other sources, also had more positive attitudes toward science (Lindner et al., 2004). Based on these data, parents or guardians, and teachers influenced students' interests in science careers.

Considering the amount of time spent with students, we understand why teachers influence students' attitudes toward academics. George (2000) reported that student outcomes were generally linked to the science training of the teachers.

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Teachers' science training affects their attitudes toward science, which in turn affects students' attitudes toward science. Students who have positive attitudes toward science have positive attitudes toward their science teacher (George, 2000). "Supportive relationships with teachers may augment students' motivation to learn and actively participate in subject domains that have traditionally held little interest for them" (Fredriksen and Rhodes, 2004, p. 46). Also affected by teachers' training in science is the teaching method used. Students prefer alternative teaching methods (activity- and inquiry-based instruction) when compared to lecture-based or traditional methods. Studies show that students' taught by these innovative methods had more positive attitudes and higher academic achievements when compared to those taught with traditional methods (Gibson and Chase, 2002). Studies show that classroom interactions, facilitated by the teacher, between students and professional scientists have positive effects on students' attitudes toward science (Bruce et al., 1997; Fougere, 1998; McKeown, 2003; Turner and Lapan, 2004).

The role of the parent in influencing their child's interests in science and/or in science careers should not be discounted. Xu (2004) discussed the importance of parents assisting and encouraging students with homework, "…students most likely to do homework with parents were those with higher grade point averages and test scores" (p. 544). By helping with homework, parents were able to influence their children's academic attitudes and goals. In contrast, a study assessing students' rates of achievement growth showed that the level of parental involvement did not affect the rate of science achievement growth (Ma and Ma, 2004). From these findings, we deduce that students who had positively influential parents or guardians generally excelled at academics, which included but did not specifically indicate science topics.

In addition to parents, siblings and peers have notable effects on students' attitudes toward science. Siblings often serve as role models, or examples of achievements and behaviors. Siblings provide comparative examples of how to live one's life, thus helping to form each others' identities (Kerka, 2000). Peers influence each others' attitudes toward science. Children's temperaments are related to how their peers view them and their level of popularity and sociability. Students with positive dispositions were those with better grades and higher academic achievements in school, while students with negative dispositions had lower grades and lower academic achievement levels in school (Gumora and Arsenio, 2002). Similar to parental influence, siblings and peers' influence on attitudes toward science mainly have an indirect effect on students' attitudes toward science.

To address the problem of middle school students' generally negative attitudes toward science, the Partnership for Environmental Education and Rural Health (PEER) was established to increase knowledge, interest, and career awareness in environmental science and health topics, using a Web-based integrated curriculum, for rural middle school (grades 6 to 8) students. The main objectives of PEER are to: 1) increase the number of public school students who enter and remain in science-based career tracks; and 2) to integrate environmental health science topics into science, mathematics, English, language arts, and social studies curricula. The objectives are achieved by three activities: Web-based curricula modules, professional teaching development programs, and scientists' classroom visits to rural middle schools. The research reported in this paper focused solely on scientists' classroom visits to rural Texas middle schools.

Purpose and Objectives

The purpose of this study was to determine the effects of scientists' classroom visits on students' science career interests in rural Texas middle schools. The following objectives guided this inquiry.

1. Determine students' interests in science careers after having been visited by a Texas A&M University scientist.
2. Determine students' information sources as influencing factors affecting their overall interests in science careers.
3. Evaluate students' interests in science careers and information sources when compared by grade level and topic (scientists' purpose of visit).

Methods

A descriptive research design was used for this study. The population for this study was middle school students from 29 rural public middle schools in Texas. The target population included all students who participated in the PEER scientists' visits (two males from the College of Veterinary Medicine) program. Both scientists were tenured professors; each had more than 25 years experience in teaching and researching environmental health sciences. The accessible population included 1643 students who attended an in-school scientist visit. Caution is warranted in generalizing the results of this study beyond the population from which the data were drawn. However, the large number of participants in the study may allow for some ecological generalizations and implications to other similar middle school settings.

The research instrument (questionnaire) used in this study was designed by the researchers to address the objectives of the study. The questionnaire had two parts; part one was designed to measure participants' interests in science careers (11 questionsfour were reverse coded). Participants were asked to indicate their interests in science careers using a four-point Likert-type scale (1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, and 4 = strongly agree). An "Interest in Science Careers" score was

calculated by summing participants' responses to the 11 statements. Example statements included, "science careers are just for males," "science careers are exciting," and "it is possible that I could become a scientist" (all statements are included in Table 2).

The second part was designed to evaluate the influence that information sources had on students' interests in science careers. Participants were asked to indicate their response by using a four-point Likert-type scale (1 = not influential, 2 = somewhat influential, 3 = influential and 4 = very influential). An "Influence of Information Source" score was calculated by summing participants' responses for the nine sources. Information sources included celebrities (TV, movie, sports, etc.), church leaders, fellow classmates, friends, government leaders, other family members, parents or guardians, school guidance counselor, and teachers.

Data were collected by visiting scientists, using a paper instrument, after having presented one of six (Water–You Thinking, Jade Dragon, Texas 1867, Smoking and Respiratory System, Air–You Forgot, or Safe Drinking Water) integrated (into science, social studies, math, and English language arts) environmental health science topics. Each classroom visit lasted from one to two hours and included a mini-presentation, small group discussion, models, and hands-on activities. A brief description of each classroom visit topic follows:

Water–You Thinking: Teams of students are taught basic water pollution principles using an interactive question-answer format. Students are asked to predict the effects of acid rain, excess fertilizer, heating, silt, and stagnation on water quality parameters. Responses are collected using keypads and a wireless audience response system. After student teams make their predictions, a student (selected from the class) perturbs the water supply (lake/river) of a small village (ceramic water fountain and city). Graphical measurements of the effects of the perturbation are projected and team responses and scores displayed. Both immediate and long-term environmental effects are considered and included in these discussions.

Jade Dragon: The Jade Dragon presentation/exercise takes sixth grade students to the Yangtze River region in China, where they follow the story of two young teenagers and their attempt to retrieve a family heirloom. During the adventure, one of the teens meets his grandfather, who is dying of lung cancer. Students are asked to find answers to a series of English, social studies, science, and mathematics problems pertaining to the grandfather's condition.

Texas 1867: Targeted to seventh grade students, Texas 1867 takes students back to the year of the terrible yellow fever epidemic. They follow the story of two teenagers who are discovering the effects of yellow fever in their community. Students learn about historical figures such as Sam Houston, the lifestyle of this period in Texas history, and the impact of epidemic diseases, which remain a problem in many parts of the world today. Processes involved in solving medical questions are explored. As in the Jade Dragon, Texas 1867 helps students learn important lessons pertaining to the world outside their classroom.

Smoking and Respiratory System: A presentation based on the anatomy and function of the respiratory system. Topic presentation included exercises, small group discussion, respiratory system models, and hands-on activities that aided students' understanding of how we breathe, the function of conducting respiratory processes (oxygen and carbon dioxide exchange), and the effects of smoking on cell function, appearance and lung condition, and its possible role in causing lung cancer.

Air–You Forgot: Presentations/exercises featuring real-time experimentation using computers, multiple projectors, air quality instrumentation, and a cast of characters (students). Teams of students are taught several basic atmospheric composition concepts using an interactive question-answer format. Students are asked to quantify the expected changes in oxygen and carbon dioxide levels in a chamber that occur following breathing the air in this chamber. Responses are collected using keypads and a wireless audience response system. After student teams make their predictions, one student (selected from the class) serves as experimenter for several experimental perturbations. The effects of burning a candle and incense in the chamber are also measured in experiments designed to assess oxygen, carbon dioxide, and carbon monoxide levels. Graphical measurements of the experiment effects are projected and team responses and scores displayed. Both immediate and long-term environmental effects are considered and included in these discussions.

Safe Drinking Water: Students discover the serious consequences of drinking water contaminated by *Enterobacteriaceae*. Through the use of 3M™ Petrifilm™ (Disclaimer: product name is for informational purposes only and does not imply endorsement) bacteriological culture plates, students learn how to test for bacteria in water. Culture techniques and incubation procedures are introduced and students conduct experiments to discover potential bacterial contaminants on their hands and in the school environment.

A panel of eight experts (middle school teacher educators) at Texas A&M University established instrument validity. The instrument scales (interests in science careers and information sources) were developed originally by one of the researchers in this study. The scales were validated previously by 24 Mississippi science and biology teachers in a National Science Foundation project (Swortzel et al., 2003).

One year before the PEER program was launched the instrument was pilot tested, with 30 middle school students not included in the target population.

Table 1. Demographic Data for Rural Texas Middle School Students (N = 1643)

Variables		*f*	Percent
Topic	Water - You Thinking	718	43.7
	Jade Dragon	282	17.2
	Texas 1867	259	15.8
	Smoking & Respiratory System	193	11.7
	Air - You Forgot	128	7.8
	Safe Drinking Water	63	3.8
Grade	Seventh	652	39.7
	Eight	528	32.1
	Sixth	407	24.8
	Fifth	56	3.4

These data were used to determine summed scale reliabilities, using the Cronbach's alpha coefficient (Cronbach, 1951). Reliabilities for the scales were: Interests in Science Careers (0.67); and Influence of Information Source (0.82). The scales in this study provided reliable data for analyses and interpretation.

Descriptive analyses were used to describe the data. Significant differences in students' summed scale scores were analyzed by grade levels and topics presented using analysis of variance tests (Hinkle et al., 1994). Rural middle school policies in Texas prohibited the researchers from collecting additional demographic data (gender, race, or socioeconomic status) to augment further the tests of significant difference between sub-groups. An alpha level of .05 was established *a priori* for tests of significant difference when analyzed by grade levels and topics presented.

Results and Discussion

Scientists' classroom visits to rural public Texas schools produced 1643 valid student response sets. Table 1 shows demographics for the scientists' visits, including topics presented and grade levels. The Water You Thinking topic was presented most often (n = 718) and seventh grade students comprised the largest audience (n = 652) (Table 1). Readers should note that some teachers invited entire schools to the scientists' classroom visits, which included mixed enrollments from fifth to eighth grade students.

Students recorded their thoughts on 11 statements measuring their interests in science careers. Table 2 shows descriptive statistics for individual statements. Students strongly agreed (M = 3.71) with the statement, "Science careers are just for males." However, they agreed also with contradicting statements: A career in science would be boring (M = 3.10), and Science careers are exciting (M = 2.89). As a group, they had high interests for careers in science (M = 30.21).

Table 3 shows descriptive statistics for the influence of students' individual information sources. Students perceived parents or guardians (M = 3.11), teachers (M = 2.86), other family members (M = 2.82), and friends (M = 2.51) as influential information sources affecting their science career interests. All other sources were viewed as somewhat influential (M = 2.10-2.40). Results are sorted by descending total grand means for individual sources (Table 3).

Significant differences were investigated by calculating an overall interest in science careers score (Summed scale scores showing perspective of students' overall interests in science careers), and analyzed by selected variables (topic and grade level). Differences occurred between groups; students who were presented the Water - You Thinking topic held significantly higher (M = 30.70) interests in science careers than did students presented the Texas 1867 (M = 29.46) or the Air - You Forgot (M = 28.70) topics (Table 4).

Fifth grade students had significantly more positive (M = 33.59) interests in science careers than did students in all other grades. In addition, eighth grade students had significantly more positive (M = 30.55) interests in science careers than did seventh grade students (M = 29.58).

To better understand students' thoughts about the overall influence of different information sources their interests in science careers, the information sources scale was summed. As a group, they thought that all information sources were "influential" on their interests in science careers. Tables 6 and 7 reveal significant differences existed in the overall influence of information sources when analyzed by topic and grade. Students who were presented the Texas 1867 topic placed significantly lower value on the influence of their information sources (M = 20.55) than did all other students who were presented all other topics. Fifth grade students placed significantly higher value on the influence of their information sources (M = 25.39) than did students in all other grades.

Table 2. Descriptive Statistics for Rural Texas Middle School Students' Interests in Science Careers

Statements	*M*	*SD*	*n*
Science careers are just for males.	3.71	.72	1626
A career in science would be boring.	3.10	1.00	1622
Ethnic minorities can have successful science careers.	3.00	1.02	1578
Science careers are exciting.	2.89	.95	1612
A career in science means having to work in a laboratory.	2.83	.97	1606
Females should seek careers in science-related areas.	2.83	1.02	1609
A science career does not mean you have to work in a lab.	2.77	1.05	1603
Science careers are for people with really good math skills.	2.62	1.01	1625
The U.S. population does not know enough about science.	2.38	1.01	1605
It is possible that I could become a scientist.	2.33	1.04	1635
Science is more enjoyable than all other subjects in middle school.	2.32	1.03	1618

Note. Likert-type scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree. Summed scale scores ranged from ranged from 14 to 44.

Summary

Interaction with scientists in the classroom can heighten rural middle school students' interests in science careers by reinforcing the influence of information source providers, enhancing teachers' efforts, and connecting classroom content to real-life situa-

Table 3. Descriptive Statistics for Rural Texas Middle School Students' Information Source Influences

Information Sources	*M*	*SD*	*n*
Parents or guardians	3.11	1.02	1583
Teachers	2.86	1.07	1585
Other family members	2.82	.97	1591
Friends	2.51	1.01	1595
Church leaders	2.40	1.11	1572
Celebrities (TV, movie, sports, etc.)	2.37	1.14	1567
School guidance counselor	2.30	1.12	1561
Fellow classmates	2.17	.94	1590
Government leaders	2.10	1.09	1561

Note. Likert-type scale: 1 = Not Influential; 2 = Somewhat Influential; 3 = Influential; 4 = Very Influential. Summed scale scores ranged from ranged from 9 to 36.

Table 4. Topic Influence on Rural Texas Middle School Students' Overall Interests in Science Careers

Variables				*M*[z]	*SD*	*n*
Topics:	Water - You Thinking			30.70[a]	5.02	718
	Jade Dragon			30.25[a]	4.79	282
	Texas 1867			29.46[b]	5.15	259
	Smoking & Respiratory System			30.52[a]	5.24	193
	Air - You Forgot			28.70[b]	4.70	128
	Safe Drinking Water			29.65[a]	5.35	63
	Total			30.21	5.05	1643
Source		*df*	*ss*	*ms*	*F*	*p*
Between Groups		5	651.87	130.37	5.18	<.001
Within Groups		1637	41178.42	25.15		
Total		1642	41830.29			

[z]Interests in Science Careers were determined by summing raw scores for each statement; scores ranged from 14 to 44. Means above the dashed line with different letters are significant at $p < .05$, based on Gabriel's post hoc analysis.

Table 5. Grade Influence on Rural Texas Middle School Students' Overall Interests in Science Careers

Variables				*M*[z]	*SD*	*n*
Grades:	Fifth			33.59[a]	4.89	56
	Eighth			30.55[b]	5.12	528
	Sixth			30.33[b]	5.20	407
	Seventh			29.58[bc]	4.76	652
	Total			30.21	5.05	1643
Source		*df*	*ss*	*ms*	*F*	*p*
Between Groups		3	967.31	322.44	12.93	<.001
Within Groups		1639	40862.98	24.93		
Total		1642	41830.29			

[z]Interests in Science Careers were determined by summing raw scores for each statement; scores ranged from 14 to 44. Means above the dashed line with different letters are significant at $p < .05$, based on Gabriel's post hoc analysis.

tions. Barman (1999) reported that students perceived professional scientists to be white males. While students in this study had the same perception (at least about science careers being just for males), they also agreed that ethnic minorities and females could have successful science careers. Their strong agreement with "Science careers are just for males," was possibly the result of all visits being conducted by males.

In a different study concerning middle school students, males showed interest in science, mathematics, and engineering-related careers, while females were interested in pursuing art and social-based occupations (Turner and Lapan, 2004). According to Turner and Lapan, this result reflects students' social experiences. Students' agreement with contradicting statements, "A career in science would be boring," and "Science careers are exciting," possibly indicated a lack of mature logical thought processes between discriminating items. PEER project coordinators are encouraged to include non-traditional scientists in the scientist visits program to show students that science careers are not limited to a specific race or gender.

Scientist visits provided variety in teaching methods used to teach science. In rural middle schools, one teacher may teach many classes, some outside of their area of expertise (Fougere, 1998). Fougere (1998) found that visiting scientists "bring authentic science into the classrooms of our potential future researchers" (p. 250). Scientist visits helped students learn about science from professionals in the field of science. When scientists involved students in experiments, students felt they were participating actively in real science, while gaining insight into the industry (Fougere, 1998). Similarly, the scientists conducting classroom visits to rural Texas middle schools created opportunities to actively engage students by using models, scientific equipment, small group discussions revolving around the scientific method, and hands-on activities to help students understand the connections between classroom science and real-world problems (e.g., pollution, ill-effects of smoking, etc.) faced by our society.

Providing a relationship between classroom science and the world around them often inspires students to learn and excel in science. According to McKeown (2003), "If students can understand a link between the science they study in the classroom and the world they live in, they are often more motivated and have better attitudes toward science. Improved attitude is often linked to greater achievement" (p. 873). A student's attitude toward a subject determines her/his pursuit of knowledge and/or a career in that area. "…A positive attitude toward a subject makes students more likely to engage in lifelong learning…and career choices" (Bruce et al., 1997, p. 72). Data from this study showed that PEER project coordinators reinforced these important career decision building processes by piquing students' interests in science careers through the scientist classroom visits program.

There is a trend of increasingly negative attitudes toward science among middle school students

Table 6. Influence of Information Sources by Topic

Variables				*M*[z]	*SD*	*n*
Topics:	Air - You Forgot			23.55[a]	6.15	128
	Safe Drinking Water			29.65[a]	5.54	63
	Smoking & Respiratory System			30.52[a]	6.30	187
	Jade Dragon			30.25[a]	5.54	281
	Water - You Thinking			30.70[a]	5.55	698
	Texas 1867			29.46[b]	6.31	254
	Total			30.21	5.87	1611
Source		*df*	*ss*	*ms*	*F*	*p*
Between Groups		5	1262.63	252.53	7.47	<.001
Within Groups		1605	54234.41	33.79		
Total		1610	55497.04			

[z]Influence of Information Sources was determined by summing raw scores for each statement; scores ranged from 9 to 36. Means above the dashed line with different letters are significant at $p < .05$, based on Gabriel's post hoc analysis.

Table 7. Influence of Information Sources by Grade

Variables				*M*[z]	*SD*	*n*
Grades:	Fifth			25.39[a]	7.27	56
	Eighth			22.53[b]	5.61	515
	Sixth			21.91[b]	5.93	399
	Seventh			21.83[b]	5.82	641
	Total			22.20	5.87	1611
Source		*df*	*ss*	*ms*	*F*	*p*
Between Groups		3	747.57	249.19	7.31	<.001
Within Groups		1607	54749.47	34.07		
Total		1610	55497.04			

[z]Influence of Information Sources was determined by summing raw scores for each statement; scores ranged from 9 to 36. Means above the dashed line with different letters are significant at $p < .05$, based on Gabriel's post hoc analysis.

as they advance through the middle grades (Ma and Wilkins, 2002). Research has shown that attitude change is most evident at 13 years of age (Cavallo and Laubach, 2001; Cohen-Scali, 2003; Gibson and Chase, 2002; Ma and Wilkins, 2002). Females, minorities, students living in single parent homes, and students' living in poor socioeconomic conditions tended to have lower interests in science (Barman, 1999; Blosser, 1990; Ma and Ma, 2004; Ma and Wilkins, 2002). While these variables were beyond the data collection permission afforded to the researchers, additional study of these variables and their effects on students' interests in science careers is needed in rural Texas middle schools.

Studies show that teachers, parents, and peers (respectively) had the most influence on middle school students' interests in science careers. When scientists visit schools, they supplement teachers' lessons, and/or provide new and interesting materials for those schools. When students interact with scientists they gain connections to science-related careers and insights into the profession. Working with scientists connects what students are taught in classrooms to the world around them. We believe that scientist visits can positively influence middle school students' interests in science careers, however this study did not allow for authentic verification of this belief. Additional research on students' pre-scientist visit attitudes toward science careers compared with their post-scientist visit attitudes is needed to verify this supposition.

Students with teachers who use activity- or inquiry-based teaching methods have more positive attitudes toward science. Children who have positive and encouraging parents or guardians, and positive relationships with their peers have more positive attitudes toward science. These findings, coupled with scientist visits to middle school classrooms may produce more positive interests in science careers among all students. Based on the findings of this study, a targeted effort should be made to incorporate more scientist visits in sixth and seventh grade classes to counter students' waning interests in science careers during those years.

Certain measures can prevent or lessen middle school student's disinterest in science careers. Parents, teachers, and other family members should inform middle school students, particularly those in grades six and seven that the science industry is not limited to Caucasian males, and that socioeconomic status does not have to be a limiting factor to a successful science career. Teachers should convey positive attitudes toward science through their instruction, and use innovative methods for teaching science, including activity- and inquiry-based teaching, rather than traditional, lecture-based teaching methods. Teachers and schools could significantly improve rural middle school students' interests in science careers by arranging scientist classroom visits for all middle school students.

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