

ABSTRACT

MELDRUM, JENETTE. Factors Contributing to Students Pursuit of Advanced Science. (Under the direction of Leonard Annetta.)

During the middle-school years student interest in science begins to decline. In this study students in grades 6 through 9 were surveyed to determine what factor(s) (peers, family, science class, teachers, and/or informal experiences) contribute to students pursuing advanced science. This study focuses on what factor(s) influence minority students to pursue advanced science courses and pursue science careers. It is well known that the minority population is increasing, however the number of minorities with careers in science is not reflective of that increase. The majority of Latino students (50%) surveyed in this study indicated that they were currently interested to very interested in science, compared to only 40% African-American students, and only 36% of Caucasian students. Upon further analysis by ANOVA and independent samples t-test significance was found for three of the factors or subscales between the three ethnicities surveyed. Family Encouragement, Science Classroom Experience, and Informal Learning Experiences, were the three subscales that showed significance. Therefore the role of parents in discussing science with their children, the science classroom environment, and opportunities for informal science learning cannot be disregarded. Further research should focus on the exact role that these three factors play in encouraging middle grade students to pursue advanced science. In addition, studies with university science majors and current scientists may be able to shed more light on how extrinsic factors, such as family, science class, and informal learning experiences influence students toward pursuing advanced science.

**FACTORS CONTRIBUTING TO STUDENTS PURSUIT OF ADVANCED
SCIENCE**

by
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BIOGRAPHY

Jenette Dean Meldrum was born on February 27, 1977, the second and youngest daughter of Patricia and John Dean. Jenette grew up in Round Hill, a small town in the foothills of the Blue Ridge Mountains in northwestern Virginia. In 1995 she graduated from Loudoun Valley High School in Purcellville, Virginia. It was in high school where Jenette developed an interest in biology.

Jenette then went on to attend Purdue University in West Lafayette, Indiana where she studied neurobiology. During her second year at Purdue, Jenette decided that she also had an interest in teaching high school biology. And so it was that Jenette continued her studies of neurobiology in addition to biology teaching. In 2000, Jenette graduated from Purdue University with a Bachelor's degree in Biology Teaching and Neurobiology. However, upon graduation, Jenette was not ready to give up the world of research.

In fall of 2000 Jenette began work on a doctorate in neuroscience at the University of North Carolina at Chapel Hill. In May 2002, Jenette began to feel a call to do something more than research and left UNC-Chapel Hill.

In January 2003, Jenette accepted an 8th grade teaching position at Smith Middle School in Chapel Hill. Throughout her teaching experience at Smith, Jenette grew to love teaching and working with students. In January of 2005, Jenette started the Masters of Science Education program at North Carolina State University in Raleigh, NC to enrich her knowledge and skills in science education.

Jenette currently lives in Durham, NC with her husband Chris, and her son Ian.

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1 - INTRODUCTION

By 12th grade, students in the United States fall near the bottom or dead last in international competitions in mathematics and science. Meanwhile the number of degrees awarded in engineering in the United States is down twenty percent from the peak year of 1985 (Business Roundtable, 2005). The U.S. continues to struggle "to sustain its scientific and technological superiority" (p. 1). While the overall number of students that graduate high school and go on to study science in college is down, minorities continue to be underrepresented in the field of science.

"Despite substantial gain over the past decade, minorities are still underrepresented in science and engineering, both in employment and training" (Clark, 2000, p. 1). According to Shirley Jackson, president of the Rensselaer Polytechnic Institute, the United States needs the "minority talent to remain competitive scientifically in the face of a changing global economy" (Ricks, 2004, p. 147). Many studies have focused on whether minority students possess positive attitudes toward science and if a positive attitude leads to success and further study of science. However, Catsambis (1995) showed that extrinsic factors such as the family, community, and school of these minority students might be more influential than intrinsic attitudes.

The influence of family has been shown to be of great importance to the success of minority students. The involvement of parents in their children's science and math education is proportional to how the students perform on science and math tests (Smith & Hausafus, 1998). Unfortunately, Hispanic and African-American parents tend to become less involved in their child's education as their child ages. As the influence of family decreases, the influence of peers tends to increase (Johnston & Viadero, 2000).

Exploring student attitudes toward science is nothing new. Researchers have been trying to figure out what factor contributes to students having a positive attitude toward science since the 1960's (Myers, 1967). As our minority population continues to grow, more and more researchers have been interested in how to increase the role of minorities in science; over 400 articles were written in the last five years alone on this topic (ERIC search November 2006). Many studies have looked at one or two specific factors and tried to find the relationship between one factor (e.g. family, peers, school resources) and student attitudes and/or achievement toward science. Yet, no study to date has examined several factors side-by-side to understand the role that each factor plays in encouraging minorities to pursue advanced science.

Taking into consideration intrinsic and extrinsic factors, such as school, family, and peers, as well as ethnicity, this study sought to answer the following questions:

1. What factors contribute to students' pursuit of advanced science?
2. Do the factors that contribute to student interest vary by ethnicity?

This study will shed light on which extrinsic factors provide the most positive influence on students in encouraging them to pursue science. Understanding the role that extrinsic factors play in whether students pursue science will help increase the presence of minorities in science careers and further make the United States once again the leader in science and technology.

2 - LITERATURE REVIEW

Minorities in science

The number of minorities entering the field of science does not reflect the growing number of minorities in the United States population. From 1990 to 2000, the United States saw a 57.9% increase in the Latino population (from 22.4 million in 1990 to 35.3 million in 2000) compared to a total U.S. population increase of only 13.2 percent (Guzman, 2001). Despite the increase in overall Latino population, Latinos are not pursuing science anywhere near that rate of increase. It has long been known that there are fewer African-American students that pursue a career in science compared to Caucasian students (Clark, 2000). In 2004, Shirley Ann Jackson, the president of the Rensselaer Polytechnic Institute, told the Annual Meeting of the American Association for the Advancement of Science that minorities will soon become the “new majority,” and will need to fill the void of retiring scientists, engineers, and technologists who are predominantly white males. Further, if the United States wants to remain competitive scientifically among a changing global economy, then we need to draw on the minority talent (Ricks, 2004).

Studies by Mickelson (1990) and Zuniga, Olson, and Winter (2005) have found that African-American and Latino students express a strong interest in science and continue on into college. However, their success in high school science and math classes tells a different story. The achievement gap between minority (African-American and Latino) and white students at one time was thought to be attributed to a phenomenon called stereotype threat (Steele & Aronson, 1995). In this construct minority students under perform on tests when asked to state their ethnicity and gender, due to a fear of

confirming the stereotype that minority students do not perform as well as white students. Regardless of attitude and self-perceived ability in math and science, minority students surveyed in a study by Valerie Maholmes (2001), said that they would be interested in a career in math or science.

Attitudes toward science

Attitudes and success in science vary from elementary school to middle school to high school, with elementary school being a time when most children have a positive attitude toward science and are performing well. The decline in attitude toward science may be attributed to the science courses taken in each grade (with more positive attitudes toward science shown for biology courses and more negative attitudes for physics courses). While attitude may be on the decline with students' increasing grade level, attitudes about the utility of science have shown an increase as students increase in grade level (George, 2006). Male students reportedly possess more positive attitudes toward science than female students. However, both males' and females' attitudes toward science decline from sixth to ninth grade and this decline in attitude was also apparent from beginning to the middle of the school year (Simpson & Oliver, 1985).

In a study by Atwater, Wiggins, and Gardner (1995) it was shown that students possessing a positive attitude in science also regarded their science teachers highly. There are mixed results as to whether attitudes toward science impact whether or not minorities will pursue advance courses in science (Atwater, Wiggins, & Gardner, 1995; Greenfield, 1996; Simpson and Oliver, 1990; Zacharia and Calabrese Barton, 2004). Simpson and Oliver (1990) and Atwater, et al. (1995) surveyed urban minority students and found that

if they had negative attitudes toward science, then they also had a negative outlook on their future in the field of science.

Student attitudes toward science can also vary depending on how science topics are presented (Zacharia & Calabrese Barton, 2004). When students worked on projects that were related to issues of power, culture, and ideology, then they generally had a positive attitude toward science. Positive attitudes come from meaningful experiences. To create a meaningful experience, students need to feel a sense of purpose in the task at hand, the language of the task should be age-appropriate, the task should be “hands-on” as well as “minds-on,” and students should have a sense of ‘wow’ during the task (Keogh & Naylor, 1997). When science is taught as an engaging, hands-on experience, science often becomes the most interesting subject for students (Howe & Jones, 1988). In addition, participation in science activities has been found to have a strong effect on science attitudes. And in turn, science attitudes have shown to have an influence on science achievement and pursuit of science careers (George & Kaplan, 1997).

The attitudes of peers, parents, and teachers of a student also indicate the success of a student in math and science. For example, a teacher’s rating of how important it was for a student to succeed and the capability of that student predicted the student’s self-perceived success and behavior. Peer predicted success also impacts a student’s own belief in his or her ability to be successful in math or science. Teachers and peers are also influential in their support of students’ behaviors and study habits (Bouchey, 2004).

Peer Influence

As students age, they become more concerned with being liked by their peers and maintaining a positive self-image, this is largely the case when students enter high

school. In a report by Johnston and Viadero (2000), it was suggested that African-American students are greatly influenced by their peers to not “act white.” Thus, African-American students taking higher level math and science courses may appear to their peers as “acting white.” Minority students surveyed, also expressed a fear of failure in higher-level classes and may see language as a barrier to success in higher-level classes (Crawley and Koballa, Jr., 1992).

The relationship between peer and individual attitudes toward science during the middle grade years (grades 6 through 9) is one that has been examined by Talton and Simpson (1985). It was found that “the strength of the relationship between peer and individual attitude toward science increases significantly over grades 6, 7, and 8 and peaks in grade 9 at the beginning of the school year” (p. 23). Thus this relationship can have positive and negative effects. Positive peer and individual attitudes toward science can result in higher achievement, while negative peer and individual attitudes can result in disinterest. Furthermore, individual attitudes may be difficult to discern from peer attitudes during the middle school years (Talton & Simpson, 1985).

Parental Influence

While the role of teachers in shaping student attitudes toward science can not be denied, the involvement of parents in their children’s education can not be ignored. When parents participate in their child’s education by talking with their children about school activities and encouraging their children in science, students are more likely to have positive attitudes toward science (George & Kaplan, 1997). The role of parents on achievement has also been examined through parenting style (Spera, 2005). The particular parenting practice that parents use on their children may differ more by

socioeconomic status (SES) than ethnicity. Research by Spera (2005) shows that when parents are involved in their children's education, students demonstrated an increased academic achievement. A parent's education level may also influence student participation in science activities. Parents with higher education are more likely to take their children to museums and science centers than those parents with low education levels (George & Kaplan, 1997).

Parents' gender-biased beliefs and perceptions may influence what subjects students study and what careers students choose to pursue. In a study by Bleeker and Jacobs (2004), students formed perceptions and interests based on the beliefs and messages that their mothers provided when the students were in sixth-grade. Students who had mothers who perceived their children to have success in math and science reported to have high self-efficacy toward a career in math or science. However, as previous research has pointed out (Atwater, Wiggins, & Gardner, 1995), there is a decline in parental involvement during the middle school years, perhaps due to parents allowing their children more autonomy (Spera, 2005).

Teacher Influence

Positive science attitudes can often be attributed to the influence of a popular science teacher. When the quality of teaching is high, attitudes also tend to be high. Attitudes tend to be learned whether from peers, family, or teachers and because they are learned, it would make sense that they could be taught as well (Papanastasiou, 2002).

Teachers also have the responsibility of creating an interesting and engaging science classroom environment. Whether the science classroom creates an inviting atmosphere that encourages students to engage in science can effect the attitudes that

students hold about science (Talton & Simpson, 1986). Students need to feel encouraged to explore and ask questions, which can help develop an interest in science.

Unfortunately, the idea that science class is “fun” seems to decline during the middle school years. As students move from elementary through middle school students also say that science becomes less interesting. Science classrooms need to make students feel comfortable and successful, however this is not the case for most seventh and eleventh graders (Yager & Penick, 1986). The role of the science classroom in the eyes of students changes from elementary to high school, no longer is science class a place of wonder and exploration, but instead it is filled with lectures and prescribed experiments.

As students move up in grade level and science subjects change from life science to earth science to physics, the anxieties that students feel about science also increases. In a survey of 1000 high school students the following science anxieties were reported: danger, test anxiety, math and problem-solving anxiety, squeamish anxiety, performance anxiety, and classroom anxiety (Wynstra & Cummings, 1993).

Middle Grades

The middle grades are often defined as grades 6-9, which includes grades 6-8 the traditional middle school grades as well as grade 9, traditionally the first year of high school. The middle school years in particular, appear to be a crucial time in developing student interest in science. Understanding the factors that influence middle school students to achieve in science was the focus of a study by Reynolds (1991). Reynolds noted that student perceptions of classroom context can influence learning of middle school students. And while Reynolds found that peers had a negative effect on the learning of science, there was no direct evidence on actual peer influence. Parental

influence was found to have only a modest effect on achievement. In addition, a study by Atwater, et al. (1995) found that middle school students regarded the influence of their friends' and families' attitudes toward science to be neutral.

Middle schools are under quite a bit of scrutiny these days as the No Child Left Behind (NCLB) act aims at improving the more than 35% of underperforming middle schools in the United States. Student achievement across all areas of middle school is lagging and this may or may not be due to increased student enrollment and out-of-field teachers in math and science, according to Anne C. Lewis (2006). Sondra Cooney the director of the Southern Regional Education Board (SREB) too is aware that middle school students are unprepared for high school and further are not aware of college entrance requirements. In schools with high-performing students, students reported that "their teachers encouraged them to do well in school" (p. 9). Cooney also links reading to success in the middle school years, "boys who reported reading an assigned book or article on a science topic at least once a week scored higher on assessment than those who did not" (p. 10). At the middle school level, it is important that teachers and parents be in communication and talk about the students progress and preparation for high school. Further, teachers who were mentors or acted as guidance counselors produced students that were higher-achieving and were more prepared to take advanced courses in high school (Cooney, 2001).

Informal Education

"There is no doubt that learning in science and technology occurs outside of school through real world experiences" (Rennie and Stocklmayer, 2003, p. 760). In so much that formal classroom education stresses science as knowledge, informal education

integrates the economic and social well-being of citizens with science as method (Sullenger, 2006). Informal education is any learning that takes place outside the formal structure of a classroom, this can be a visit to a museum, a hike in the woods, television program, or a trip to the beach – any place where there is an opportunity to learn about science through one’s own experience. From the viewpoint of a constructivist, learning is individualistic, therefore no two visitors to a museum will have the same learning experience (Anderson, Lucas, & Ginns, 2003).

In order for museums and science exhibits to create positive attitudes toward science, the exhibits must be interactive and understood without a staff member present. Further, exhibits should appeal to an audience of various ages (Russell, 2005). It is important for museum staff to understand that visitors choose to visit their museum and also choose to view certain exhibits. In this way, visitors decide what part of the museum visit is meaningful and therefore what they will learn (Rennie and Stockmayer, 2003).

Summary

Attitudes are intrinsic in nature, but research by Catsambis (1995) has shown that extrinsic factors such as families, communities, and the school environment of these minority students may be what are contributing to low-level science achievement among minorities. In the Handbook of Research on Science Teaching and Learning, (1994, p. 211) Simpson, Koballa, Oliver, and Crawley state, “the key to successes in education often depends on how a student feels toward home, self and school.” The role of family and community has long been shown to be an influential factor in the success of minority students. Smith and Hausafus (1998) suggest that parents need to be made aware of the importance of science and mathematics education. Further, children who are encouraged

by their parents to take advanced science and math courses and are advised as to the importance of science and math education, perform better on science and math tests. If this is the case, then it is alarming to hear that as students get older, Hispanic and African-American parents become less involved in their child's education (Johnston & Viadero, 2000). Less parental involvement isn't necessarily a bad thing, according to a study on Hispanic attitudes toward enrolling in chemistry (Crawley & Koballa, Jr., 1992). They found that when the Hispanic-American students are given more autonomy in their selection of coursework and career path they will choose to be enrolled in advanced science courses.

Minorities' interest in science needs to grow if the United States is going to fill in the gaps of its retiring scientists (Ricks, 2002) and if minorities are going to achieve their full potential. Whether it is parental influence or engaging students in science that is meaningful (Zacharia and Calabrese Barton, 2004), we need to know what encourages minority students to pursue a career in science. Minorities are the new "majority" and this should be reflected not only in the general population but also in the field of science.

3 - METHODS

Participants

Participants were a convenient sample of students in grades sixth through ninth with each grade representing a different school, except the sample of ninth graders which came from two different schools. The sample for this study consisted of 50 sixth graders, 77 seventh graders, 78 eighth graders, and 60 ninth graders (29 from one school and 31 from another school) from the Raleigh-Durham area of North Carolina. All students in the study were currently enrolled in science classes. The classes from which the sample was taken were heterogeneous with regard to ability, gender, and ethnicity, having been randomly assigned. The ethnic composition of the total sample was 67% White/Caucasian, 25% African-American, and 8% Latino (see Figure 1 for ethnic composition of each grade level surveyed).

Measures

Student attitudes and interests in science were assessed using a combination of statements from questionnaires developed and validated in previous studies (Simpson & Oliver, 1990; Stake & Mares, 2001) and newly developed statements that were validated by a panel of experts in science education. This combination of statements formed the instrument called The Science Interest Survey (see Appendix A). The Science Interest Survey included 20 statements measuring five subscales based on previous research evidence on factors that influence science interest (see Appendix B). The five subscales examined were: (1) Family Encouragement, (2) Peer Attitudes Toward Science, (3) Teacher Influence, (4) Informal Learning Experiences (such as museum visits and other science related field trips), and (5) Science Classroom Experiences. Each subscale

consisted of four-statements and was measured using a 5-point Likert scale (1-strongly disagree to 5-strongly agree). The family encouragement measure was taken from Stake and Mares (2001) and had a calculated internal validity of .85. Teacher encouragement and peer attitudes toward science were based on statements similar to those developed by Simpson and Troost (1982). Informal learning experiences and science classroom experiences statements were developed for the purpose of this study. The Science Interest Survey and subscale statements are included in the Appendix. Participants were also asked to describe their current interest in science by circling one of five words that best described their current feeling from “dislike it” to “very interested.”

Procedures

365 copies of the Science Interest Survey were mailed among the six teachers participating in the study. Students in these teachers' classes filled out the survey in their science classroom during their science class period. Surveys were not permitted to leave the classroom. Students completed the survey individually without assistance from their science teacher or peers. The science teacher of these students then collected the surveys and mailed the completed surveys to the researcher. Of the 365 surveys that were mailed among the six teachers, 335 surveys were returned to the researcher. The researcher sorted the completed surveys by ethnicity. Ethnic groups that contained 4 or less student completed surveys per class were discarded, as were incomplete surveys., and surveys completed by students not in grades 6-9 (some 11th and 12th graders completed the survey because they were enrolled in a first year biology course with a majority of 9th graders). Out of the 335 returned surveys, 62 were discarded due to the conditions mentioned above, resulting in a sample size of 265.

The sample of 273 surveys (from all five schools) was entered individually into a Microsoft Excel spreadsheet. The response frequency and mean for each statement was found according to ethnicity and was calculated using the Statistical Package for the Social Sciences (SPSS). If survey statements were stated negatively they were reflected when scored and used for the subscale and survey scores. The mean for each subscale was determined for each ethnicity. Each subscale was compared through analysis of variance (ANOVA) as a function of student ethnicity. Because the subscales consisted of more than one statement, a z-score was created by calculating the mean for each student response on the respective subscale statements. In this way, a new variable was created for each subscale (e.g. "Teacher z") and used for the ANOVA analysis. Three follow-up Independent Samples T-tests were performed to compare individual ethnicities as a function against the five separate subscales (Family Encouragement, Peer Attitudes Toward Science, Teacher Influence, Informal Learning Experiences, and Science Classroom Experiences).

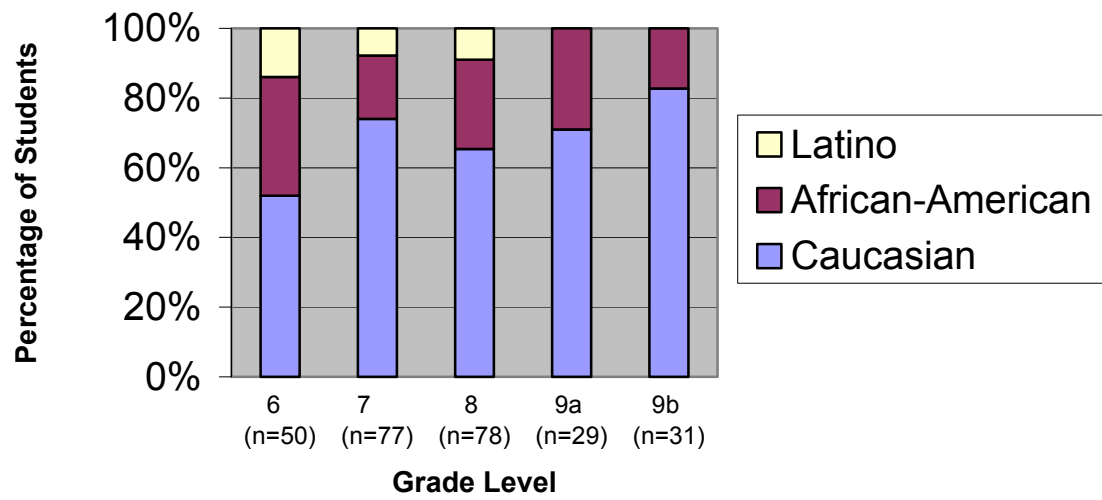


Figure 1. Percentage of ethnicities surveyed per grade level.

3 - RESULTS

Science Interest Survey

Completed Science Interest Surveys from 273 students (180 Caucasian students, 65 African-American students, and 28 Latino students) served as the basis for analysis. Means for each of the five subscales (together made up the Science Interest Survey) Family-z, Peers-z, Teachers-z, Informal Experiences-z, and Science Class-z for each ethnic group were calculated and served as the basis for statistical analysis. Descriptive statistics of study participants are illustrated in Table 1.

Table 1

Descriptive Statistics for Science Interest Survey by Subscale and Ethnicity

Subscale	Ethnicity	N	Mean	SD
FAMILY	Caucasian	179	3.10	0.80
	African-American	65	2.87	0.76
	Latino	28	3.11	0.57
	Total	272	3.05	0.77
PEERS	Caucasian	180	2.70	0.76
	African-American	65	2.65	0.75
	Latino	28	2.94	0.68
	Total	273	2.72	0.75
TEACHERS	Caucasian	180	3.80	0.94
	African-American	65	3.86	1.05
	Latino	28	3.98	0.82
	Total	273	3.83	0.96
INFORMAL EXPERIENCES	Caucasian	180	3.15	0.76
	African-American	65	3.02	0.80
	Latino	28	3.38	0.63
	Total	273	3.14	0.76
SCIENCE CLASS	Caucasian	180	3.14	0.87
	African-American	65	3.17	0.92
	Latino	28	3.54	0.62
	Total	273	3.19	0.87

**Note.* Mean scores are ratings on a 1 (strongly disagree) – to 5 (strongly agree) point scale.

Level of agreement for each subscale and ethnicity was assessed using a five-by-three analysis of variance (ANOVA). The means of each subscale for each ethnic group (Caucasian, African-American, and Latino) were used to determine a standard or z score which was used in statistical analysis. This ANOVA analysis was deemed significant at an alpha of .05. Table 2 shows the analysis of variance data. The results of the ANOVA failed to show significance between the three ethnicities and the five subscales. An Independent Samples T-test was performed to compare individual ethnicities against each of the five subscales. The results from the Independent Samples T-test are shown in Table 3.

Table 2

Analysis of Variance of Ethnicity Effect on the Science Interest Survey Subscales

Subscale		Sum of Squares	df	Mean Square	F	P-value
FAMILY	Between Groups	2.79	2.00	1.39	2.37	0.10
	Within Groups	158.14	269.00	0.59		
	Total	160.93	271.00			
PEERS	Between Groups	1.66	2.00	0.83	1.47	0.23
	Within Groups	152.39	270.00	0.56		
	Total	154.04	272.00			
TEACHERS	Between Groups	0.91	2.00	0.45	0.49	0.61
	Within Groups	249.22	270.00	0.92		
	Total	250.12	272.00			
INFORMAL EXPERIENCES	Between Groups	2.45	2.00	1.23	2.14	0.12
	Within Groups	154.73	270.00	0.57		
	Total	157.18	272.00			
SCIENCE CLASS	Between Groups	3.79	2.00	1.89	2.55	0.08
	Within Groups	200.84	270.00	0.74		
	Total	204.63	272.00			

Caucasian vs. African-American Students

Analyzing the independent samples t-test for Caucasian and African-American students, only one subscale reached significance. The subscale Family Encouragement had a significance level of $p < .04$ (for $p < .05$). These results indicate that among Caucasian and African-American students, family plays a significant role in encouraging students to pursue science.

African-American vs. Latino Students

Examining the results of the independent samples t-test for African-American versus Latino students, again, only one subscale demonstrated significance. Informal Learning Experiences had a significance value of $p < .04$ (for $p < .05$). Informal learning experiences are often overlooked, but these results indicate that informal learning plays a significant role in the interest that students have in science.

Caucasian vs. Latino Students

Comparing the independent samples t-test for Caucasian and Latino students, also showed significance for only one subscale. Science Classroom Experiences reached a significance of $p < .02$ (for $p < .05$). The science classroom experience that a student has therefore plays a key role in whether a student finds science interesting and perhaps will pursue advanced science.

Table 3
Independent Samples T-tests for Equality of Means of Subscales Between Ethnicities

Subscale	<u>Caucasian vs. African-American</u>			<u>African-American vs. Latino</u>			<u>Caucasian vs. Latino</u>		
	t	df	P-value	t	df	P-value	t	df	P-value
FAMILY	2.08	242	0.04	-1.52	91	0.13	-0.03	205	0.97
PEERS	0.45	243	0.66	-1.73	91	0.09	-1.53	206	0.13
TEACHERS	0.99	243	-0.46	-0.54	91	0.59	-0.98	206	0.33
INFORMAL EXPERIENCES	1.14	243	0.26	-2.06	91	0.04	-1.49	206	0.14
SCIENCE CLASS	-0.25	243	0.81	-1.91	91	0.06	-2.30	206	0.02

The frequency of responses to each statement on the Science Interest Survey was calculated and grouped according to subscale. The frequency of 4's and 5's (the highest possible scores that could be given based on the Science Interest Survey 5-point Likert scale) given to each subscale by each ethnic group studied was organized and ranked (Figure 2). All three ethnic groups studied gave more 4's and 5's to the subscale Teacher Encouragement than to any of the other subscales. Peer Influence received the least number of 4's and 5's from all ethnic groups, indicating that peers have less influence than teachers when it comes to pursuing science for middle grade students.

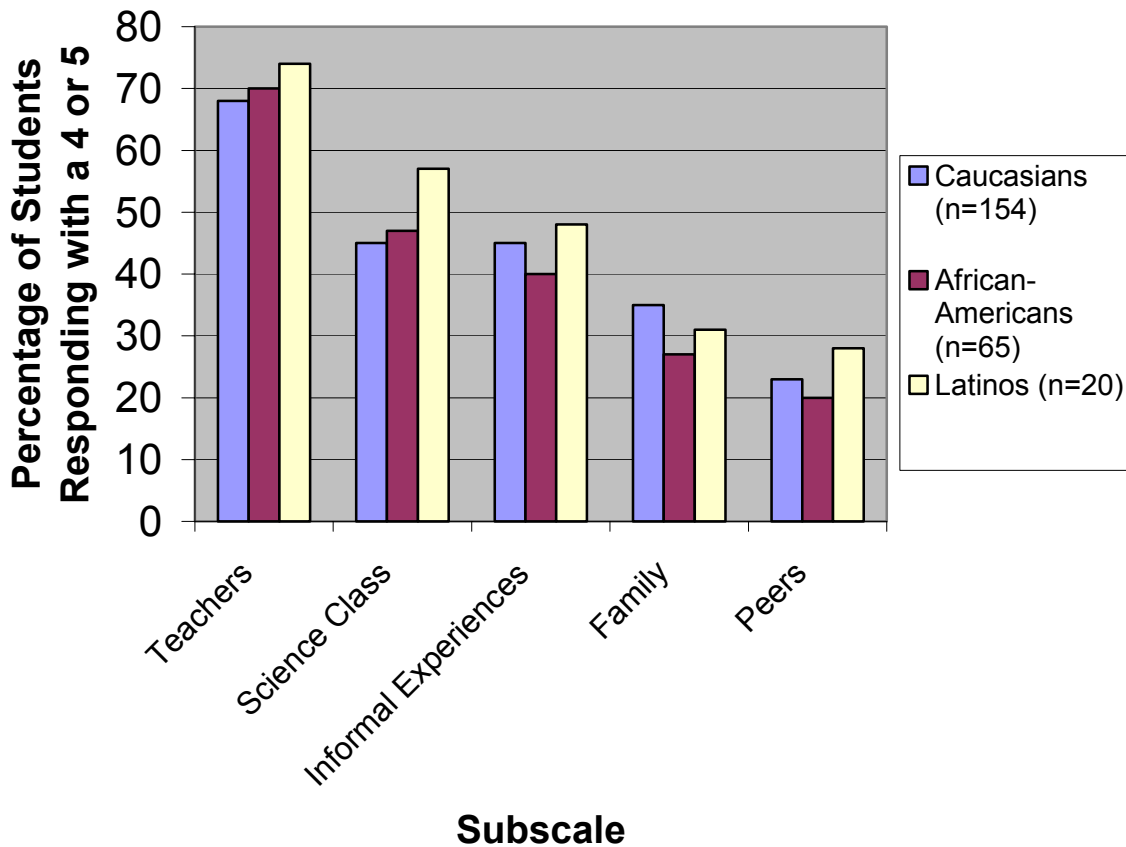


Figure 2. Percentage of students responding with a 4 or 5 for each subscale.

Current Interest in Science

Students were asked to rate their current interest in science using a 5-point Likert scale, from 1-dislike it to 5-very interested. The majority of Latino students (50%) answered that they were currently *interested* to *very interested* in science (Figure 3), compared to only 40% of African-American students and 36% of Caucasian students who were surveyed. Caucasian students made up the largest percentage (45%), followed by African-American students (43%) who expressed their current interest in science as *not really interested* to *dislike it*. Latinos had the smallest percentage of students (11%) who expressed disinterest in science, but also had the largest percentage of students (39%) of students who were *not sure* about their current interest in science.

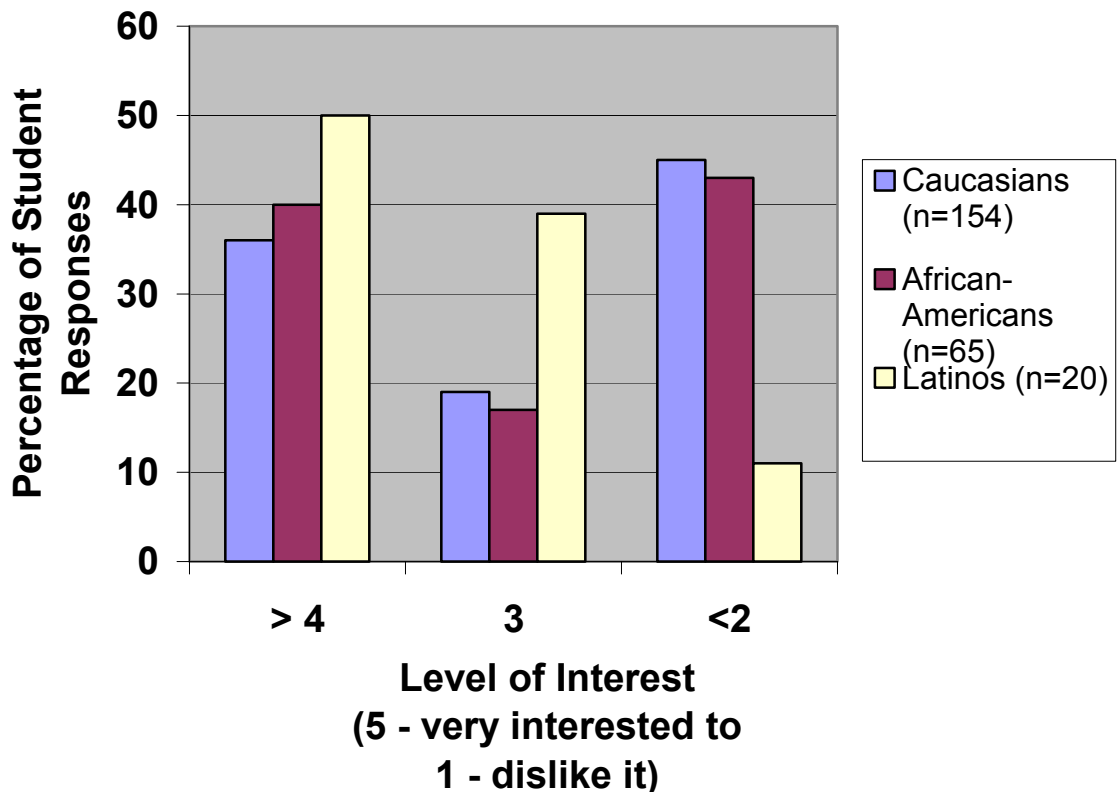


Figure 3. Students' level of current interest in science.

4 - DISCUSSION

The results of this study suggest that over 40% of Caucasians surveyed are currently *not* interested in science. From this study it appears that Caucasian students have made up their minds about science, by ninth grade they are either interested in science and will continue on to take advanced science courses, or they have lost their interest in science. The majority of Latino students surveyed are interested in science, however the majority of African-American and Caucasian students surveyed expressed disinterest in science. It appears that between grades 6 and 9, Caucasian and African-American students have made up their mind about science, either they are interested in science or they are not. Even with 40% of African-American students expressing an interest in science, this does not explain why so few African-Americans (and Latinos) are entering the field of science as adults. Almost 40% of Latinos selected *not sure* as to their current interest in science – the largest of all three ethnic groups. What this means isn't clear, however it does tell us is that if this large group of Latino students hasn't made up their mind about science, there is still time to positively influence this growing minority to pursue a career in science.

Three subscales from the Science Interest Survey were noted areas of significance when comparing the three ethnic groups, Family Encouragement, Science Classroom Experiences, and Informal Learning Experiences. Noting these three areas of significance, one can then look at how these extrinsic factors contribute to student interest in science.

Caucasian vs. African-American Students

The role of family in encouraging students to pursue science according to the results of this study is significant for Caucasian students, but not as important for African-American students. Caucasian students had a mean score for Family Encouragement of 3.10 compared to 2.87 for African-American students. Many researchers have reported on the role that parents in particular play in encouraging students to pursue science (Yager and Penick, 1986; Smith and Hausafus, 1998; Bouchey, 2004). This study supports previous data that suggests that students will be higher achievers in science as well as more interested in science if parents take an interest in the science courses that their child takes and encourages their child to pursue a career in science.

African-American vs. Latino Students

The role of informal learning experiences as a factor contributing toward attitude and interest toward science is one that has not been well researched. New light from this study suggests that Latino students in particular are positively influenced toward science from informal learning experiences such as visiting a museum or science center. The fact that Latino students (even more so than African-American students) responded positively to statements about informal learning experiences suggests that class field trips are not a waste of time or money if it means that it will keep students (particularly minority students) interested in science.

Caucasian vs. Latino Students

For Caucasian and Latino students the subscale of significance was Science Classroom Experiences. The role of the science classroom can be ambiguous since a

science classroom is comprised of science equipment, a teacher, peers, and a certain atmosphere. However, the science classroom was important to this set of Caucasian students that were surveyed for this study (more so than the Latino students surveyed). What aspect of the science classroom influences Caucasian students is not certain, however, from the Science Interest Survey, it would appear that the amount and type of science equipment present in the classroom and how often the equipment is used are likely contributing to Caucasian student interest.

Limitations

Despite the lack of statistical significance from the ANOVA results, further examination through independent samples t-tests showed significance among three subscales (Family Encouragement, Science Classroom Experience, and Informal Experiences) between the three ethnicities studied. These results indicate that students are influenced by their parents, science classroom environment, and field trips when it comes to pursuing advanced science. While the two remaining subscales (Peer Influence and Teacher Influence) did not show significance, one can not rule out the role that peers and teachers play in the science classroom experience. In order to further find determine the role that family, science classrooms, and informal experiences and all of the factors examined in this study play in determining if students pursue science, a follow-up study should be conducted on current university science majors and current scientists. Understanding why university students chose to study science and why people have chosen science as a career can further help educators encourage students to become scientists.

In addition, the role of gender and socioeconomic status (SES) in addition need not be ignored. Both of these factors may also be indirectly affecting whether minority students choose to take advanced science courses and pursue science careers. Females are less likely than males to pursue science careers and students with a low socioeconomic status are even more unlikely to take advanced science courses and continue on to college (Von Secker & Lissitz, 1999). In this study the role of gender was not examined. However, a similar study that asked students to report their gender may result in differences in responses by males and females. Further, the examination of responses by gender may also differ by ethnicity, adding yet another component to this study and more information about how to attract minority and female students to the sciences.

Previously it was shown that interest in science is high during the elementary school years and starts to decline during middle school (Atwater, et al., 1995). While this study did not focus on specific grade levels of middle school, it should be noted that the samples used in this study were from single classes from various schools in North Carolina. Therefore, teacher bias may have contributed to student responses in this study.

The number of minority students in this study was considerably less than the number of Caucasian students in this study. The responses of these Latino and African-American students are just a small fraction of the greater minority population in North Carolina. A larger study with more Latino and African-American students is needed to elucidate the findings in this study. Surveying more students (particularly minority students) from various school systems across the state of North Carolina would allow researchers more insight into what factors influence students to pursue advanced science.

Further studies could also include interviewing students in 11th and 12th grade that are and are not enrolled in advanced science courses, to determine what has led them to follow these paths.

Implications

What we do know is that the number of minorities that do pursue a career in science is not representative of the total minority population (Ricks, 2002). The field of science is still largely a field employed by the Caucasian majority. It is unclear why Latinos have the highest percentage of students interested in science and yet currently there are few Latino scientists. Perhaps negative stereotyping of Latinos and African-Americans by their teachers and peers (Bouchey, 2004) is partly to blame. Research by Tyson, Darity, Jr. and Castellino (2005) has found that being a high achieving minority is no longer “acting white.” African-American students that are high achievers responded that they are not racially peer pressured against high academic achievement. So, what is getting in the way of minorities pursuing science? Is socioeconomic status a factor? Does the availability of resources to our minority students factor in to what courses minority students choose to take and whether they will pursue a career in science? Some researchers have had much success in science summer and outreach programs (Hanesian & Perna, 1999) that expose students to real world applications of science and technology that is not available in schools and that these students would otherwise not have access to. Perhaps more funding needs to be directed to these types of science outreach programs. From this study it is clear that informal science education is a significant factor in pursuing our minority students to pursue science. Beyond what we know about the roles of informal education and the science classroom environment, further research needs to

occur in order to understand why minority students are not choosing to pursue advance science courses.

Several studies (Atwater, et al., 1995; Simpson & Oliver, 1985) have demonstrated that student interest in science decreases with increasing grade level. It has been hypothesized that this decline in science attitude is due to the content taught in the science class (Simpson & Oliver, 1985) with physics and earth science receiving low attitude scores compared to the higher attitudes of students enrolled in biology or life science courses. One approach to increase student interest would be to integrate life science with physical science and earth science. Teaching science as a whole rather than in separate compartmentalized subjects as they are currently. Often when students come to middle school, it is the first time that they have been exposed to a science class. Reforming the elementary science curriculum to include more physical and earth science and better preparing students for middle school science is yet another way to increase positive attitudes toward science.

While most of us would agree that challenging students is a good thing, we need to be careful that when we teach science that it does not become too difficult so that students are no longer interested in science. In a report from Newsweek “Why my kids hate science,” the author reported that elementary school children begin to hate science because they are given the impression that science is difficult, boring, and has no place in their everyday lives (Hazen, 1991). We need to make sure that science is approachable for all students on all academic levels, because in addition to preparing our future scientists, one of our goals should still be to prepare scientific literate citizens.

This study has shown that the science class environment plays a significant role in creating positive attitudes toward science. However the role of the science classroom has not been completely uncovered. Because teachers and peers also make up the science class environment, one must also look at how science teachers and peers can contribute to a positive science class experience. Science teachers have the opportunity to be powerful and encouraging role models to our students. But what exactly should teachers be doing to encourage students to pursue science? Does a teacher's gender or ethnicity play a role in whether students choose to take advance science courses? We know that teacher quality is reflected in the level of classroom teaching, but what defines a quality science teacher? Are quality and influential science teachers those with more than five years experience, holders of advanced degrees and certifications, or active participants in professional development? Creating a positive and encouraging science classroom experience also goes beyond the teacher and one must look at the quality and quantity of materials that are available to students. Do students have access to resources like those used by professional scientists (internet, microscopes, dissection tools, etc.)? How often are students engaged in hands-on learning? Are students encouraged to work in cooperative learning groups? All of these questions deal with just a few aspects that make up the science classroom environment. Answering these questions and others could help educators understand how to make science more accessible and more inviting to our students and hopefully encourage our students to pursue advanced science courses in high school and continue on to study science in college.

As the United States gets ready to begin another science education reform, it is important that families, teachers, and informal educators understand their role in leading

students to pursue advanced science. This study shows that families, the science classroom, and informal learning experiences play key roles in encouraging students to pursue science. Students should be provided with the opportunities for hands-on learning with real-life applications and value. Developing a sense of ownership and interest in science is key for many students to even consider studying science beyond the required coursework of high school. As mentioned previously, the science classroom is comprised of peers, the science teacher, as well as the available science equipment and resources. Creating a science classroom that encourages inquiry and provides encouragement will provide a lasting impression that science is interesting and has real value. Because science teachers play such a large role in the science classroom, special attention should be given to them. These are our students' role models and therefore science teachers likewise should be encouraged and have available to them resources such as science conferences, teaching methods workshops, innovative science teaching materials, and technology. Empowering science teachers with these resources will encourage them to be enthusiastic about science and to be able to pass on their enthusiasm and love of science to their students.

As much as teachers are role models for students, the same holds true for parents and adult family members. This study shows that family encouragement was significant in influencing students positively toward science. Families do not have to know or understand a lot about science in order to encourage their students to take an interest in science. Families can support students by engaging in conversation about their student's science class activities and lessons, taking nature hikes, or visiting local museums, aquariums, and zoos. Parents can also encourage their children to become involved in

science clubs and science competitions at their school as well as designing and performing science experiments at home. Parents often forget how much influence and impact they have on their children and often leave the teaching and academic support to teachers. It is time for parents and teachers to now come together and work as a team in promoting the pursuit of science. Teachers can send students home with science activities to try at home with family members. And conversely students should be encouraged to share informal learning experiences with his or her science class. This study supports the notion that the science classroom environment, informal learning experiences, and family encouragement are all three important when it comes to positively influencing students to pursue advanced science.

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APPENDICES

Appendix A: Science Interest Survey

Appendix A shows the Science Interest Survey that was distributed to all participants of this study. Teachers of the participants handed out the Science Interest Survey and instructed students on how to fill out the survey. Surveys were completed in class and collected by the teachers. Teachers either mailed or hand delivered completed surveys to the researcher.

Science Interest Survey

Grade: _____ **Age:** _____ **School:** _____

Please check your race/ethnicity or describe by the box marked “other.”

White/Caucasian Black/African-American Latino (from Mexico, Central, or South America)

Asian American Indian or Alaskan Native Hawaiian or Pacific Islander Other:

Directions: Read each statement. Circle the number that describes how you feel about each statement. From 1 – strongly disagree to 5 – strongly agree.

	strongly disagree	disagree	don't know	agree	strongly agree
	1	2	3	4	5
My family has encouraged me to study science.	1	2	3	4	5
My friends do not like science.	1	2	3	4	5
My science teachers encourage me to do my best.	1	2	3	4	5
I do not enjoy visiting science museums and science centers.	1	2	3	4	5
The topics taught in my science class are important in the real world.	1	2	3	4	5
Visiting science museums and exhibits makes me consider a career in science.	1	2	3	4	5
People in my family are not interested in science.	1	2	3	4	5
My science teachers have encouraged me to learn about science.	1	2	3	4	5
My friends view science as nerdy.	1	2	3	4	5
My family is enthusiastic about a science career for me.	1	2	3	4	5
Visiting science museums and exhibits makes me want to learn more about a science topic.	1	2	3	4	5
My friends do not like to watch science programs on T.V.	1	2	3	4	5
My family is interested in the science courses I take.	1	2	3	4	5
I prefer science class to visiting science museums and centers.	1	2	3	4	5
My science teachers make science interesting.	1	2	3	4	5
The topics taught in my science class are boring.	1	2	3	4	5
My science classroom has interesting equipment.	1	2	3	4	5
My friends perform science experiments outside of school.	1	2	3	4	5
We do not use most of the equipment in our science classroom.	1	2	3	4	5

My science teachers are enthusiastic about science. 1 2 3 4 5

What word best describes your current interest in science? (please circle)

dislike it not really interested not sure interested very interested

Appendix B: Science Interest Survey Subscale Statements

Appendix B shows the sets of statements organized by subscale that together comprised the Science Interest Survey.

Science Interest Survey – Subscale Statements

Family Encouragement

1. My family has encouraged me to study science.
2. People in my family are not interested in science.
3. My family is enthusiastic about a science career for me.
4. My family is interested in the science courses I take.

Peer Attitudes Toward Science

1. My friends do not like science.
2. My friends view science as nerdy.
3. My friends do not like to watch science programs on T.V.
4. My friends perform science experiments outside of school.

Teacher Influence

1. My science teachers encourage me to do my best.
2. My science teachers have encouraged me to learn about science.
3. My science teachers make science interesting.
4. My science teachers are enthusiastic about science.

Informal Learning Experiences

1. I do not enjoy visiting science museums and science centers.
2. Visiting science museums and exhibits makes me consider a career in science.
3. Visiting science museums and exhibits makes me want to learn more about a science topic.
4. I prefer science class to visiting science museums and centers.

Science Classroom Experiences

1. The topics taught in my science class are important in the real world.
2. The topics taught in my science class are boring.
3. My science classroom has interesting equipment.
4. We do not use most of the equipment in our science classroom.