The Development of Science Identity: An Evaluation of Youth Development Programs at the Museum of Science and Industry, Chicago

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LOYOLA UNIVERSITY CHICAGO

THE DEVELOPMENT OF SCIENCE_IDENTITY:
AN EVALUATION OF YOUTH DEVELOPMENT PROGRAMS AT THE MUSEUM
OF SCIENCE AND INDUSTRY, CHICAGO

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE GRADUATE SCHOOL
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

PROGRAM IN APPLIED SOCIAL PSYCHOLOGY

BY
SAMUEL EDWARD COLE
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<thead>
<tr>
<th>Acronym</th>
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<tr>
<td>ANCOVA</td>
<td>Analysis of Covariance</td>
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<td>ANOVA</td>
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<td>ACT</td>
<td>American College Testing</td>
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<td>Chicago Public Schools</td>
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<td>Hierarchical Linear Modeling</td>
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<td>Multigroup Ethnic Identity Measure</td>
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<td>MRC</td>
<td>Multiple Regression and Correlation</td>
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<td>MSI</td>
<td>Museum of Science and Industry</td>
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<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<tr>
<td>NCLB</td>
<td>No Child Left Behind</td>
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<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Cooperation and Development</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences</td>
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ABSTRACT

The following dissertation presents findings from a year-long evaluation of informal scientific education programs at the Museum of Science and Industry in Chicago, Illinois. Science identity, rather than scientific knowledge, was the analytic lens through which the programs’ effectiveness was assessed. A goal of the Museum generally, and the programs specifically, is to increase public identification with the field of science. Science identity was assessed using a novel survey instrument and three focus groups. Hierarchical linear models found a positive relationship between time enrolled in the Science Minors program and the development of science identity. These analyses also point to a negative relationship between a student’s desire to work and science identity development. Focus group discussions suggest that the Minors and Achievers programs enhance interest in science and teach students how to be better communicators.
CHAPTER ONE

CURRENT STATE OF SCIENCE EDUCATION IN THE UNITED STATES

...the most pervasive concern was considered to be the state of United States K-12 education, which on average is a laggard among industrial economies—while costing more per student than any other OECD country. So where does America stand relative to its position of five years ago when the [original] Gathering Storm report was prepared? The unanimous view of the committee members participating in the preparation of this report is that our nation’s outlook has worsened.

(p. 4)

- Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5, 2010

The quote above is the ominous conclusion of the National Academies’ 2010 update to the United States Congress regarding the actions policymakers can take to enhance the science and technology enterprises in the United States. The original “Gathering Storm” report was commissioned by the United States House of Representatives and Senate in 2005 to assess Americans’ ability to compete for jobs in the global marketplace. The link between quality jobs and the nation’s quality of life is continuously stressed throughout the report, and innovations in science and engineering are touted as the primary drivers of economic growth and quality jobs, “The possession of quality jobs is the foundation of a high quality life for the nation’s
citizenry” (p. 2). In addition, “over the long term the great majority of newly created jobs are the indirect or direct result of advancement of science and technology” (p. 18). The Gathering Storm committee developed four general recommendations in response to Congress’ request. The “committee’s unanimous highest priority” (p. 20) was to, “Move the United States K-12 education system in science and mathematics to a leading position by global standards” (p. 19). In this way, the committee hoped to increase America’s talent pool and create the necessary conditions for driving innovation in the future. Improving science education, as well as encouraging citizens to pursue scientific careers, promoting investment, and providing a beneficial legal atmosphere for innovation, was described as necessary to maintaining and improving the quality of life for the US population. Endemic poor science education will only chip away at the nation’s ability to develop innovative technologies and will continue to have a negative impact on the entire nation’s quality of life.

The National Academies’ report includes a multitude of examples that help to put a meaningful face on this “Gathering Storm” (p. 8-11). The list below contains only a subset of facts that pertain specifically to science education. Many more not listed here describe the similarly ominous economic and political climates that threaten to reduce the number and quality of opportunities for future generations of Americans.

- Forty-nine percent of United States adults do not know how long it takes for the Earth to revolve around the Sun.
- The World Economic Forum ranks the United States 48th in quality of mathematics and science education.
• According to the ACT College Readiness report, 78 percent of high school graduates did not meet the readiness benchmark levels for one or more entry-level college courses in mathematics, science, reading and English.

• Youths between the ages of 8 and 18 average seven-and-a-half hours a day in front of video games, television and computers—often multi-tasking.

• The average American K-12 student spends four hours a day in front of a TV.

• Thirty years ago, ten percent of California’s general fund went to higher education and three percent to prisons. Today, nearly eleven percent goes to prisons and eight percent to higher education.

• In 2000 the number of foreign students studying the physical sciences and engineering in United States graduate schools for the first time surpassed the number of United States students.

• Sixty-nine percent of United States public school students in fifth through eighth grade are taught mathematics by a teacher without a degree or certificate in mathematics.

• Ninety-three percent of United States public school students in fifth through eighth grade are taught the physical sciences by a teacher without a degree or certificate in the physical sciences.

• The United States ranks 27th among developed nations in the proportion of college students receiving undergraduate degrees in science or engineering.

• The United States ranks 20th in high school completion rate among industrialized nations and 16th in college completion rate.

• The United States has fallen from first to eleventh place in the OECD in the fraction 25-34 year olds that has graduated high school. The older portion of the U.S. workforce ranks first among OECD populations of the same age.

• The increase in cost of higher education in America has substantially surpassed the growth in family income in recent decades. United States current and former students have amassed $633 billion in student loan debt.
The sentiment described throughout the “Gathering Storm” report was echoed during President Barack Obama’s 2011 State of the Union address. The President’s address focused generally on the poor state of American education and the need for investment in science and math education. In his speech, he specifically referenced the historical significance of the launch of Sputnik and the ensuing space race, and he correctly asserted that investment in research and education “unleashed a wave of innovation that created new industries and millions of new jobs.”

While both the President and Congress are aware of this gathering storm, it appears that little has been done to alleviate the problem. In fact, in many states science education is actively threatened. For example, the founding principal of evolution that forms the basis of all of biology education is constantly under threat in public schools (see Berkman & Plutzer, 2011 for a review). There is also a growing suspicion that all of science is under threat in the United States (Krugman, 2011). This suspicion is hard to ignore when the Republican GOP platform in Texas currently includes the following language:

We oppose the teaching of Higher Order Thinking Skills (HOTS) (values clarification), critical thinking skills and similar programs that are simply a relabeling of Outcome-Based Education (OBE) (mastery learning) which focus on behavior modification and have the purpose of challenging the student's fixed beliefs and undermining parental authority. (Republican Party of Texas, 2012)
The Gathering Storm report may not have gone far enough in their recommendations if there are such active and hostile parties contributing to the problem of poor science education.

**Purpose**

The problem described in the Gathering Storm report may appear much too large to tackle. Fortunately, a network of informal science education institutions (museums, zoos, aquariums, etc.) across the U.S. is designed to do just that. The present study was conceived to contribute, if even in a small way, to the improvement of science education in the U.S. by evaluating informal science education and youth development programs at Chicago’s Museum of Science and Industry (hereafter referred to as the Museum).

A pretest-posttest design was used to measure the development of a science identity in students who enrolled in the Museum’s programs. Additional, older groups of students were also recruited in order to observe the development of a science identity across programs and age groups. Focus groups were used to provide additional depth and insight into the effectiveness of these programs and explored possible improvements to these programs. Rather than examine the programs’ effect on scientific knowledge, the present study examined effects on students’ identity as a “science person.” In this way science is regarded not as a body of knowledge, but rather as a community of practice complete with norms, behaviors, and group boundaries (Wenger, 1998).
**Science Minors and Science Achievers**

In addition to several world-class, modern, and interactive exhibits, the Museum provides several community initiatives for after-school leaders as well as middle-school to high-school aged youth through its Center for the Advancement of Science Education. The two programs of interest to the proposed study are the Science Minors and Science Achievers programs. These programs were selected primarily due to a need for meaningful evaluation conducted of these groups and a lack of prior evaluation for these programs. A brief needs-assessment with Museum staff determined that these programs could use added evaluation, as their resources were stretched thin.

The Science Minors program, hereafter referred to simply as Minors, is a youth development program for high school students between the ages of 14 and 17. The program reaches students from the Chicago Public School (CPS) system, as well as the Greater Chicagoland Area, and Northwest Indiana. At the time of this study no formal recruiting or advertising was used for the Minors program. According to Museum staff, most students learned about the program through word of mouth. The Minors program is listed, along with more than 200 other non-profit organizations, on the CPS website (www.servicelearning.cps.k12.il.us/agencies.aspx).

The Minors program runs during the CPS school year from September to June. Each year of programming is split into three sessions with different students recruited for each session. Fall sessions generally run from September to November, winter sessions from December to March, and spring sessions from April to June. Each Minors
session consists of 10 weeks of Saturday morning meetings where students learn about a specific scientific topic, scientific careers, and public speaking skills. The topic of the session is unknown to students when they sign up for the program and the topic changes with each successive session. In the fall of 2010, for example, students learned about nanotechnology. Other topics since that time have included physics and music, green technology automobiles, health and nutrition, and cardio-pulmonary science.

Minors students meet for three hours on a Saturday morning. During this time students listen to a lecture from an instructor or guest speaker and perform a lab activity or demonstration relevant to the topic at hand. Depending on the topic, experts from local universities (University of Chicago, University of Illinois, Illinois Institute of Technology) or local industries (hospitals, Microsoft) share their expertise with students. Participating students can also volunteer to conduct interactive demonstrations of the topic about which they have been learning for visitors to the Museum. At the end of each Minors program, students present what they have learned in a science fair/poster session format for their families and Museum staff.

Minors earn 30 service-learning hours if they attend all 10 Minors sessions and an additional 10 hours for presenting throughout the Museum. Students can only enroll in the Minors program once, but can graduate into the Science Achievers program after volunteering for additional 10 hours (50 hours total following enrollment in Minors), and committing to volunteer another 12 hours a month after that.
The Achievers program requires a greater commitment of time and energy than the Minors program and is less structured. In the Achievers program, students do not participate in a classroom experience on a regular basis the way they do in the Minors program; instead, they are trained to present scientific topics to Museum visitors. The Museum cross-trains Achievers on the scientific topics related to the exhibits at the Museum. In addition to the instruction in substantive knowledge, Achievers are taught communication skills relating to body language, expressions, and public speaking. Achievers are eventually stationed throughout the Museum at interactive exhibits and given the opportunity to engage museum visitors. A single Achiever can speak with over 100 guests in a single Saturday.

At the time of this writing, the Museum has several new interactive exhibits in which students are stationed and present short demonstrations related to the topic of that exhibit. For example, the “You! the Experience” exhibit contains interactive sections on health and nutrition, medical technologies, reproduction and development, and neuroscience. The “Science Storms” exhibit contains a Tesla coil that generates lightning, a 40-foot tornado, and a 30-foot tsunami wave tank.

A third group of students was also included in the current study. During the summer of 2011, several students who had graduated from the Achievers program were at the Museum for training as part of a summer internship. These students were considered to have completed both the Minors and Achievers programs. This group of students was surveyed and their responses were included in between groups analyses in
order to probe the outcome measures of interest following program completion. Throughout this report, these students are referred to as Graduates.

**Identity as an Outcome Variable**

The current study employs the appropriate but somewhat novel use of measures of identity as the variable of interest rather than focusing on the improvement of students’ scientific knowledge. Researchers have recently argued that learning science requires an identity shift and that traditional methods for teaching science are not meeting students’ needs (see Tytler et al., 2008 for a review).

It is important to note that the modern concept of identity is a relatively recent addition to the human experience. Historically, identity was closely tied to an individual’s job, geography, and family until approximately the 1800’s (Baumeister, 1986; Côté, 1996). Since this time, individual identity has grown more abstract, possibly as a result of greater technological change and occupational opportunities. As the centrality of traditional factors (i.e., occupation, geography, family) have waned over the centuries, individuals were forced to negotiate, and renegotiate, a more abstract form of identity through their own choices and achievements. This broad view of identity from a historically fixed concept to something more abstract is particularly relevant to the idea of science identity because science, or scientist, has not been a possible form of identity for all. Historically women and minority ethnic groups have been underrepresented in and discouraged from pursuing careers in science (NSF, 2011).
Erik Erikson’s (1968) classic work on psychosocial development influenced the conception of identity used in the present study. For Erikson, identity development is the process of solidifying one’s meaning, purpose, and direction in life. This process reaches its height during adolescence in Erikson’s fifth stage of psychosocial development. During adolescence one experiences increased freedom, responsibility, maturation, and power. For these reasons identity formation is more intense at this point in life and is particularly relevant to the present study. Minors and Achievers are generally in their mid to late teens, precisely the age group that Erikson uses to define adolescence, between 14 and 20 years. Erikson’s research suggests that the age group of students used in the present study is appropriate because identity formation is likely to be at or close to its peak. A study of identity development in older adults or toddlers would not be as appropriate.

More recent research specifically with regard to forms of science identity tempers the optimism that Erikson’s work offers. Specifically, it is possible that most adolescents make a decision about whether or not to pursue a scientific degree or career by the age of 14 (Tai et al., 2006; The Royal Society, 2006). Both studies present evidence that suggest that the best time to help students develop science identity is prior to their eligibility for the Minors program.

Tajfel and Turner’s (2004) social identity theory (SIT) provides the theoretical framework in which science identity is measured in the present study. SIT states that in order for someone to be a member of a group, he or she has to self-categorize as a
member of that group and be identified by others as part of that group. Furthermore, through social comparison processes individuals categorize others into in-groups if they appear to be in the same social category and into an out-group if they are markedly different. This process of social comparison is crucial to the present study. In the light of SIT, fostering the development of science identity will be more successful if the in-group presented to students is more inclusive. An exclusive group made of up of well-educated, older, white males would be one in which many students would not be able to self-categorize as members, and thus not identify with. If, however, scientists as a social category contain males, females, whites, Blacks, Asians, Hispanics, young, old, this category may be easier for students to find some similarity with, and thus foster social identification.

The use of identity rather than knowledge as the analytic lens of choice allows science learning to be viewed as a process of socialization rather than the accumulation of knowledge (Gee, 2000-01; Brickhouse & Potter, 2001; Brown, 2004; Carlone & Johnson, 2007). Considering that scientific degree programs and professions are exclusive groups or “communities of practice” (Wenger, 1998), it is essential that factors that encourage or inhibit group membership be investigated. This is especially pertinent for students that do not fit the stereotypically masculine characteristics of scientists (Brickhouse, 1994; Brickhouse & Potter, 2001; Carlone & Johnson, 2007). The use of identity as an outcome variable also allows for the investigation of individual characteristics that contribute to or limit success in scientific fields, how students judge
science as worth their time and effort, and how the development of a science identity might influence those students who want to become scientists (Cobb, 2004).

One ultimate goal of the following study is to aid in the struggle for more equitable science education. Prior research (Brickhouse, 1994; Brickhouse & Potter, 2001; Carlone & Johnson, 2007; Seymour & Hewitt, 1997) has demonstrated that the difficult conditions that students encounter in university-level programs are congruent with white-male norms, thus making it easier for white males to succeed in such fields. Science is also commonly viewed as male-dominated (Clark, 1986) and masculine (Vockell & Lobonc, 1981). In order to diversify scientific fields and provide opportunities in scientific careers, it is necessary to investigate the factors that contribute to a scientific identity of students from minority groups such as women and African Americans.

The evaluation team at the Museum agreed that students’ identification with the field of science was an appropriate outcome variable. The exhibits and programming at the Museum are designed, in part, to increase visitors’ and students’ level of identification with the scientific enterprise in general. A recent review from the National Research Council (Fenichel & Schweingruber, 2010) described six “strands of science learning” that the Museum employs as a framework for both their programs and exhibits. These strands are: 1) Sparking Interest and Excitement; 2) Understanding Scientific Content and Knowledge; 3) Engaging in Scientific Reasoning; 4) Reflecting on Science; 5) Using the Tools and Language of Science; and 6) Identifying with the
Scientific Enterprise. The sixth strand is described as “coming to think of oneself as a science learner and developing an identity as someone who knows about, uses, and sometimes contributes to science” (p. 27).

While the sixth strand in this framework stresses identification with the scientific enterprise, the other strands could also play a role in formulating science identity. The first strand addresses the need to design informal education experiences that engage emotions such as excitement and wonder. Without an emotional investment in science, students would not proceed with the more technical aspects of the field. This may be one pathway through which the Museum develops science identity.

Strands two through five focus on the more technical aspects of doing science. These can be interpreted as introducing students to the norms and practices associated with being a scientist. It is important to note that these are not just focused on going through the motions of using test tubes or memorizing the periodic table of elements. Strands three and four specifically stress using science as a way to understand the world. This understanding is at the core of identifying oneself as a science person. Even if students never pursue a scientific degree or work in a lab, possessing an understanding of science will allow them to identify with the scientific discipline and appreciate its functions and value in society.

In addition to evaluating the Minors and Achievers programs, the present study also carries more general implications for the social psychological study of identity. This presents the opportunity to test social identity theory under novel conditions. First of
all, research regarding science identity is sparse and fairly recent. Carlone and Johnson’s (2007) recent study of the development of science identity employed ethnographic interviews. The current study aims to expand on their findings using primarily quantitative methods.

For the predominantly African American students served by these programs, the common stereotype of a white male scientist constitutes a distinct out-group. Investigating how these students come to identify with such a distinct out-group, if they do at all, is very pertinent to social identity theory and social psychology in general.

Most importantly, this study is an opportunity to apply the knowledge and methods of social psychology for a tangible benefit. Many of the students enrolled in the Minors and Achievers programs are provided with minimal science resources in their own schools. This may not be a local phenomenon either. Evidence presented since the passage of No Child Left Behind (NCLB), which focuses on math, reading, and writing, demonstrates the possibility of a negative impact on other areas of education, including science education (Griffith & Scharmann, 2008). Furthermore, the Gathering Storm (2010) report referenced earlier was released after this law was in full effect. If science education has indeed been reduced in public schools, then the role of informal education institutions such as the Museum has become that much more important.

Findings from the current study may provide useful information that will benefit future students in these programs. More generally, raising the bar for science education may contribute to increasing the quality of life of the average American through greater
participation in scientific endeavors and the creation of a greater number of higher-quality jobs in the future.

**Measuring Science Identity**

The literature on science identity is predominantly ethnographic in nature (Brickhouse & Potter, 2001; Brown, 2004; Carlone & Johnson, 2007). Because there was no preexisting, valid, and reliable measure of science identity, a novel 15-item instrument was developed from similar identity measures focused on math identity as well as ethnic identity. To create this measurement instrument, several aspects of identity research were explored. Details of instrument development specifically are presented in Chapter 5.

**Implicit Measures of Identity.** Implicit measures of identity were initially considered for this project. Research by Nosek, Banaji, and Greenwald (2002) investigated implicit attitudes towards math using their Implicit Association Test (IAT). Rather than simply measure implicit attitudes, they modified their IAT to measure the association between self and math, thus creating a measure of identity.

This study found that associating self-primes with female primes more quickly made it more difficult to associate math primes with self-primes. From this they concluded that math is viewed as a more masculine pursuit by participants. Similarly, Smyth, Greenwald, and Nosek (in press) created a Gender-Science-Arts IAT to measure the associations between gender primes (male and female) and science/arts primes. This study determined that implicit science-male stereotypes were correlated positively
with majoring in science, technology, education, or math (STEM) for men but negatively for women. While the goal of that project was slightly different than the current study, a similar approach would have been useful in the investigation of science identity because gender stereotypes are also a concern within the discipline of science.

In order to use the implicit measurement paradigm, it would have been necessary to develop a science identity IAT and to assure the participating students had access to a computer in order to take the test. This type of IAT procedure, while interesting, was not practical or cost effective for the present project. Therefore, explicit measures were used instead.

**Explicit Measures of Identity.** The Nosek, Banaji, and Greenwald (2002) study described above also employed an explicit measure of science identity that consisted of three questions:

1. Do you consider yourself to be more mathematical or more artistic?
2. I consider myself to be a ‘math person’
3. I consider myself to be an ‘arts person.’

Each item was measured on a 100-point feeling thermometer rather than a Likert scale. Identity scores were calculated by combining question 1 with the difference scores of items 2 and 3. While simple, this method for measuring self-identification as a “math person” assumes math people and arts people fall on opposite ends of the same continuum without addressing other forms of identity. This scoring approach is problematic because someone who considers himself or herself to be both an art and
math person may be just as much of a science person as someone who is not an art person. The entire field of architecture, for example, readily combines art with mathematical concepts. In addition, great thinkers, such as Leonardo Da Vinci, provide a powerful example of people who are masters of both fields. For reasons such as these, Nosek et al.’s (2002) method was considered to involve an inappropriate assumption for the present study. Instead, in the present research science identity was conceptualized as but one possible identity in the mosaic of a student’s personality.

**Social Identity Theory.** As described above, Tajfel and Turner’s (2004) social identity theory (SIT) provided the established theoretical framework in which to develop a meaningful science identity survey instrument. SIT provided three key dimensions that were incorporated into the present study’s measure of science identity. First, the group with which students self-identify was defined. “Scientist” was considered too specific and not applicable to teenagers due to the specialized criteria and advanced education necessary for membership. The broader term “science person” was deemed more appropriate, as described below. Second, it was necessary to include a measure of the extent to which students self-identify as a “science person.” Third, it was necessary to determine the extent to which others categorize students as members “science people.”

**Science person.** It was anticipated at the outset of this study that use of the term “scientist” would generate very low identification scores with little variance due to the elite social and professional nature of the category. In addition, scientists have
significantly more education than the students who participate in these programs. The use of “science person” provides a less rigid group that is age appropriate for the population that participates in the Minors and Achievers programs.

While at first glance the category “science person” is broad, when rated next to (not in contrast with) similar categories such as a musical person, artistic person, or athletic person, the term describes a distinct subset of people within the larger context of a student’s experience. Including multiple categories also allows for the potential overlap of these forms of identity. Students can identify strongly with all or none of these. A similar explicit conceptualization of identity was also used in the education literature. In particular, Gee (2000-2001) defined identity as “…a certain ‘kind of person,’ in a given context” (p. 99).

Further evidence comes from research specifically on science identity. Carlone and Johnson’s 2007 study provides anecdotal support for the use of “science person” in identity research. In this ethnographic study of science identity among successful women of color, several participants detailed the subtle and sometimes blatant impact gender played in their experiences in scientific degree programs and labs. The authors attribute these women’s successful formation of a scientific identity to renegotiating and redefining what it means to be a scientist. Rather than fit the mold of what they were socialized to believe scientists are, they created a different “science identity” that fit them individually. This study provides evidence that science identity can have fuzzy boundaries and can vary between individuals.
**Synthesis.** Measuring the extent to which participants in informal science education programs identify as a “science person” as a means to evaluating science education programs draws on classic and contemporary research of identity and identity development (Brickhouse & Potter, 2001; Brown, 2004; Carlone & Johnson, 2007; Erikson, 1968; Gee, 2000-01; Tajfel & Turner, 2004). Furthermore, fostering science identity is an explicit tenet in the design of such programs (Fenichel & Schweingruber, 2010). The Minors and Achievers programs at the Museum of Science and Industry may be useful tools in the struggle to provide quality job opportunities and a better quality of life for others. The present study hopes to contribute in some small way to this meaningful enterprise by evaluating these programs and providing insight into the effects they have on participating high school students.
CHAPTER TWO

HYPOTHESES

Two groups of hypotheses were tested in order to investigate the impact of the Museum’s programs on science identity. Hypothesis group 1 was tested using a pretest-posttest design with Minors students only. Hypothesis group 2 was tested using a between-groups design and investigated differences between Minors, Achievers, and Graduates. Both groups of hypotheses used science identity, as assessed by the 15-item measure described in the previous chapter, as the sole dependent variable.

**Hypothesis Group 1**

**Hypothesis 1.** The primary hypothesis of this study predicted that Minors students would show significantly higher levels of science identity at the end of the program. This prediction was based on the expressed purpose of the programs to increase identification with the scientific enterprise as described in the National Research Council’s recent review (Fenichel & Schweingruber, 2010). The sixth strand of science learning that the Museum employs as a framework for both their programs is described as “coming to think of oneself as a science learner and developing an identity as someone who knows about, uses, and sometimes contributes to science” (p. 27).
Informal observations of the Minors program provided multiple instances of Museum staff fostering science identity. On several occasions the instructor would encourage students to “work together as scientists” during a group activity. In addition, when students struggled to organize materials or read instructions, the instructor would suggest a different approach and say something similar to “this is what a scientist would do.”

Hypotheses 1a-1f, described below, focused on the impact of six potential moderating variables that may predict differences in students’ science identity development during the Minors program. Each of these six hypotheses was tested independently.

**Hypothesis 1a.** Based on the experiences of female scientists described in prior research (Brickhouse, 1994; Brickhouse & Potter, 2001; Carlone & Johnson, 2007), it was predicted that male students would demonstrate higher levels of science identification at both time points (i.e., pretest and posttest). The stereotypically male nature of scientific fields would be expected to facilitate higher levels of science identity in male students. While this hypothesis was based on the author’s interpretation of prior research, the experiences of Museum staff led to a different prediction. Staff experiences suggested, on the contrary, that there was very little difference between males and females in terms of science identity. Fortunately, tests of hypothesis 1a provided the opportunity to address both possibilities. In the HLM framework, described in detail in Chapter 3, a statistically significant, positive \( \beta_{00} \) value would reflect
higher intercept terms for male students at both time points, which would provide supporting evidence for hypothesis 1a.

Prior research did not provide guidance as to whether science identity would be expected to change at different rates for males and females over the course of the Minors program. On the one hand, the Minors program could increase any disparity between the genders and benefit male students more than female students. On the other, it was possible that if women began with a lower level of science identity, they would have more room to grow and show greater science identity development. In addition, there was nothing to indicate that there are any gender biases in the program. Although a possible source of gender bias could be from the gender of Museum staff, male and female staff members were almost equally represented among Museum staff. Thus, it was difficult to predict any possible direction of student gender on change in science identity. A statistically significant, positive or negative level-2 slope ($\beta_{10}$) in the HLM framework would support hypothesis 1a.

**Hypothesis 1b.** This hypothesis predicted that the development of science identity would be dampened by a student’s desire to find a job as soon as possible. Museum staff believed that students who felt strongly about finding a job as soon as they were able would exhibit less science identity development at the end of the program. Staff related multiple cases were students would not continue beyond the Minors program because they would rather work than volunteer at the Museum. In essence, what Museum staff was describing, from the perspective of identity research,
may have been the resolution of multiple identities (Deaux & Burke, 2010; Settles, Sellers, & Damas, 2002). On the other hand, it may be the case that students that participate in the Minors program enter the program with established identities that do not mesh with a science identity. Recent research has demonstrated that occupational choice, at least, is predominantly decided by the age of 14. For example, Tai et al.’s (2006) analysis of the US National Educational Longitudinal Study (NELS) concluded that 14-year-old students who expected to have a science-related career were significantly (i.e., 3.4 times) more likely to earn a physical science or engineering degree than those 14-year-olds who had different career expectations. Furthermore, a retrospective study conducted by the Royal Society (2006) asked practicing scientists when they started thinking about pursuing a scientific career. This study found that over half of the 1,141 participants (63%) reported starting to think about scientific careers before the age of 14. Students who choose to work on the weekends rather than attend educational programming and volunteer at the Museum may have already formed an identity that is opposed to the development of science identity.

In the survey instrument, students were asked: “How important is the following to you: Getting a job as soon as possible” as a means of assessing the importance of finding a job. Responses were measured on a 9-point scale that ranged from “not important” to “very important.” Hypothesis 1b would be supported by a statistically significant, negative level-2 slope ($\beta_{10}$) in the HLM framework.
**Hypothesis 1c.** In contrast to hypothesis 1b, hypothesis 1c predicts a positive association between a student’s desire to graduate college and rate of science identity growth. For example, students who plan to attend and graduate from college would be more expected to be receptive to developing a science identity. The item, “How important is the following to you: Graduating college?”, was used with the same 9-point rating scale described above.

Hypothesis 1c would be supported by a statistically significant, positive level-2 slope ($\beta_{10}$) in the HLM framework.

**Hypothesis 1d.** Students whose accomplishments in science were recognized by others were also predicted to have a higher science identity growth rate. Carlone and Johnson’s (2007) research provides evidence that recognition from important others contributes to a sense of science identity. This fits with the idea of social categorization that is crucial for social identity formation (Tajfel & Turner, 2004). Individuals categorize themselves into groups, and recognition from others validates those categories. Thus, recognition was measured in the present study using the following three items on a 9-point scale that ranged from “never” to “always.”

1. How often does your family/caregiver(s) recognize your work/accomplishments in science?
2. How often do your friends recognize your work/accomplishments in science?
3. How often do your teachers/instructors recognize your work/accomplishments in science?

Hypothesis 1d would also be supported by a statistically significant, positive level-2 slope ($\beta_{10}$) in the HLM framework.
Hypothesis 1e. The Museum tries to foster development of a science identity by increasing students’ interest in science. One that the Museum uses to generate interest, and thus identity, is by giving Minors and Achievers identification badge that grant them free access to the Museum during viewing hours. Previous research has demonstrated that development of science identity requires extended time periods of contact with the scientific community (see Fenichel & Schweingruber, 2010 for a review).

In the survey instrument, students were asked: “Since you have been enrolled in Science Minors, how many times have you visited the Museum on your own time?” This created a true continuous (ratio level) scale where a score of zero meant the absolute absence of visits on one’s own time. Furthermore, hypothesis 1e was tested using the number of visits students reported making to the Museum during their time in the Minors program. For this reason, posttest values were used to test hypothesis 1e. A statistically significant, positive level-2 slope ($\beta_{10}$) in the HLM framework would provide support for hypothesis 1e.

Hypothesis 1f. In 1997, the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine devoted an entire report to the importance of mentors for students in science and engineering. This report concluded, in part, that “mentoring is likely to enhance students’ educational experience, morale, career planning and placement, and professional competence” (p. 65.). Furthermore, recent research has demonstrated the importance of mentors especially in groups that
have been underrepresented in the sciences (Brickhouse & Potter, 2001; Brown, 2004; Carlone & Johnson, 2007).

Museum staff felt similarly about the importance of mentors to students’ sense of science identity. It was predicted that students who indicate they have a science mentor would demonstrate higher levels of science identity, as well as a larger effect of the Minors program. This variable was also of interest to the Museum staff and was measured by a yes or no answer to the item, “Is there someone in your life that you would consider to be a “science mentor?” A statistically significant, positive level-2 slope ($\beta_{10}$) in the HLM framework would provide support for hypothesis 1f.

**Hypothesis Group 2**

Hypothesis group 2 tested the same predictions as group 1, but did so using varying program-levels (Minors, Achievers, and Graduates) and between groups-designs (ANOVA and hierarchical multiple regression). This approach allows for a broader view of the impact of the programs on science identity beyond the Minors program.

**Hypothesis 2.** Hypothesis 2 predicted that science identity would be at its lowest levels among pretest Minors students, higher for Achievers, and even higher for Graduates. The logic of hypothesis 2 resembles that of Hypothesis 1: namely, the more time students are enrolled in the programs, the stronger their sense of identity will become. This outcome can be described as a main effect of the program-type independent variable. Program refers to the level of programming that each student is enrolled in (Minors, Achievers, or Graduates).
As in hypothesis group 1, several moderating variables were tested in hypothesis group 2. These moderator variables are identical to those used in hypothesis group 1 and were selected for the same theoretical reasons. Brief descriptions of each of the six hypotheses in hypothesis group 2 (hypotheses 2a-2f) are presented below.

**Hypothesis 2a.** Male were predicted to demonstrate higher levels of science identity compared to female students in all groups, as well as greater development between programs. A significant main effect of gender and a significant program type X gender interaction would provide support for hypothesis 2a.

**Hypothesis 2b.** A stronger desire to find a job as soon as possible was predicted to inhibit the Hypothesis 2 effect. A significant interaction effect between Program and students’ desire to work will provide support for hypothesis 2b.

**Hypothesis 2c.** Students who feel more strongly about graduating college were predicted to show a stronger hypothesis 2 effect, compared to students who feel less strongly about graduating college. A significant two-way interaction between Program and students’ desire to graduate college would provide support for hypothesis 2c.

**Hypothesis 2d.** The extent to which others recognize students’ scientific achievements was predicted to enhance the hypothesis 2 effect. As above, a significant two-way interaction between Program and recognition of students’ would provide support for hypothesis 2d.

**Hypothesis 2e.** Students who spent more time at the Museum outside of the programs were predicted to report higher levels of science identity in all three program
levels (i.e., Minors, Achievers, and Graduates). A significant main effect of students’
time at the Museum would provide support for hypothesis 2e.

**Hypothesis 2f.** Students who have a science mentor were predicted to report
higher levels of science identity in all three groups. A significant two-way interaction
between program type and having a science mentor provide support for hypothesis 2f.
CHAPTER THREE

HYPOTHESIS 1 ANALYSIS PLAN - HIERARCHICAL LINEAR MODELING

Advantages of HLM

Hierarchical linear modeling (HLM) was the preferred method for testing hypothesis group 1 due to the hierarchical structure of the data. In this design time points (i.e., pretest and posttest), are nested within individuals. For the following discussion, it is important to note that in the HLM framework, the term “level-1” refers to the regression equation that describes an individual’s growth over time (see equation 1, below) and “level-2” refers to the set of equations that describes how individual growth is affected by individual difference variables (see equations 2, below). Raudenbush and Bryk’s (2002) notation for growth models is used below and throughout this report.

\[
\text{Level-1: } Y_{ti} = \pi_{0i} + \pi_{1i}t_i + e_{ti} \tag{1}
\]

\[
\text{Level-2: } \pi_{0i} = \beta_{00} + r_{0i} \quad \pi_{1i} = \beta_{10} + r_{1i} \tag{2}
\]

In analyzing such longitudinal data, HLM provides several statistical advantages over repeated-measures analysis of variance (ANOVA). First, it allows for the estimation
of each individual’s change in science identity over time and how this change relates to
the person’s initial levels of identity. HLM further provides the opportunity to explore
how change over time is affected by individual difference characteristics (Raudenbush &
Bryk, 2002; Wu, 1996). This analytic capability is of prime importance for the present
study, since hypotheses 1a-1f concern the impact of individual differences on the
development of science identity over time.

Future research on the topic of science identity could further exploit key
advantages of HLM by including additional time points, and measuring time
continuously (i.e., on a weekly or monthly basis as opposed to at pretest and posttest).
HLM also allows variances of measured variables to vary across time, whereas repeated-
measures ANOVA does not. This is an especially important advantage in research
designs that include more than two time-points. In these situations, covariances
between measurements will likely be larger for greater time disparities than for smaller
ones. Repeated-measures ANOVA, on the other hand, requires that variances for the
same measures at each time point and covariances between the same measures across
time points be equal (i.e., the assumption of compound symmetry). HLM is not bound
by compound symmetry and allows for the separate estimation of variances at each
time point.

For the present study, the needs of the Museum required that Minors only be
measured twice. A more complete study would measure cohorts of students from the
time they enroll in the Minors program and continue to measure them even if they did
not continue on to Achievers. While attrition from the program would likely lead to
attrition from study, this too could be accommodated to an extent by HLM. In contrast,
repeated-measures ANOVA models could not be used in this instance, as they require
complete data for all cases included in the analysis (Raudenbush & Bryk, 2002; Wu,
1996).

The hypothetical longitudinal design that measures time more fluidly (not just at
pretest and posttest) would also allow HLM to explore the possibility that development
of science identity does not occur in a simple linear manner. Along these lines,
incorporation of a quadratic regression-term at level-1 is possible (Raudenbush & Bryk,
2002).

\[ Y_{ti} = \pi_{0i} + \pi_{1i}(a_{ti} - L) + \pi_{2i}(a_{ti} - L)^2 + e_{ti} \] (3)

Here, time is represented using \( a_{ti} \) with \( L \) representing an a priori centering
constant. In short, repeated-measures ANOVA does not provide the analytic flexibility
that HLM does.

**Previous Research Using HLM**

Helson, Jones, and Kwan (2002) employed linear and quadratic models in a 40-
year longitudinal study that took advantage of HLM’s abilities to account for missing
data and explore non-linear effects. The study examined three cohorts of respondents
between 1958 and 1996. No cohort was measured at the same age or in the same year,
thus creating a problem for repeated-measures analyses. Rather than requiring each cohort to be complete, these overlapping cohorts were used in the HLM framework. In this case, age was used as a level-1 predictor and cohort as a level-2 predictor.

HLM provided the authors with the ability to investigate individual differences in rates of personality development. In addition, HLM enabled a direct test of the hypothesis that personality development occurs primarily during young adulthood and plateaus with age. This hypothesis implies a non-linear relationship between age and personality development that was tested using the following level-1 model:

$$Y_{t_i} = \pi_{0i} + \pi_{1i}(a_{t_i} - 43) + \pi_{2i}(a_{t_i} - 43)^2 + e_{t_i}$$  \hspace{1cm} (4)

The authors chose the centering constant of 43 because 43 years of age was the age closest to the mean for their entire sample. This approach created a situation where the constant ($\pi_{0i}$) described an individual’s personality score at the age of 43.

The cohorts used in the Helson et al. (2002) study were roughly measured concurrently with participants born in the 1920s and 1930s. Terracciano, McCrae, and Costa (2005), however, took further advantage of HLM’s flexibility with missing data to conduct an “accelerated” longitudinal study. In this latter study, researchers recruited cohorts of participants at the same point in time, but recruited disparate age groups. While the Helson et al.’s cohorts overlapped for the majority of the study, the cohorts in Terracciano et al.’s study did not overlap. The HLM approach provided researchers with
a tool not only to analyze a longitudinal study in a relatively short amount of time, but also to obtain an estimate of longitudinal effects over a broad age-span.

**Use of HLM in the Present Study**

The HLM model in the current study is limited to two time-points and a single level-2 variable per hypothesis. Change over time can only be linear in this study because variables were measured only twice. Testing curvilinear effects requires measurement at three or more time-points (Raudenbush & Bryk, 2002).

The test of hypothesis 1 requires the use of an unconditional model that does not specify any level-2 (student level) variables. In testing the unconditional model using the HLM software, it is important to clarify the meaning of fixed and random effects. In this case, fixed effects refer to those in which all levels of the variable of interest are included in the design. In the present study, the pretest-posttest variable is the key fixed effect. It is important to note that conclusions related to fixed effects are only generalizable to the levels included in the study. Random effects, on the other hand, refer to variables in which all levels may not be represented in the data. In the present study, random effects refers to the estimation of variance components related to the fixed effects (Raudenbush & Bryk, 2002)

Testing hypothesis 1 with the HLM equations 1 and 2 above, provides tests for both the impact of the program ($\beta_{10}$) on science identity ($Y_{ti}$) as well as an estimation of the variances to be explained by the level-2 variables ($r_{0i}$ and $r_{1i}$). As described in Chapter 2, a statistically significant, positive value for $\beta_{10}$ would confirm hypothesis 1.
Significant levels of variance at level-2 will provide evidence that students differ in pretest levels of science identity ($r_{0i}$) and that students differ in the effect the Minors program has on them ($r_{1i}$). If these values are not significantly different from zero, then incorporation of variables at level-2 will not provide any explanatory power because there would be no variance to explain.

The unconditional model also provides an estimate of science identity at time = 0. Dummy coding the time variable so that pretest = 0 and posttest = 1 means $\beta_{00}$ represents the average level of science identity for all students at pretest.

Testing of hypotheses 1a-1f requires the development of what Raudenbush and Bryk (2002) refer to as “intercepts- and slopes-as-outcomes models” (p. 23). The level-1 model will remain the same as equation 3 above. Each hypothesis in group 1, however, will require a unique level-2 specification. Since each hypothesis is testing a single level-2 variable, each model will follow the format below:

\[
\pi_{0i} = \beta_{00} + \beta_{0q}X_{qi} + r_{0i} \\
\pi_{1i} = \beta_{10} + \beta_{1q}X_{qi} + r_{1i}
\]

In most cases, tests of $\beta_{1q}$ will provide the test for each hypothesis. For example, hypothesis 1a predicts that gender will influence the effect of the Minors program on science identity. A statistically significant $\beta_{1q}$ value would provide support for this non-directional hypothesis. Gender will be dummy-coded so that 0 represents males and 1
represents females. Thus, a statistically significant, positive $\beta_{1q}$ value would indicate that the Minors program increased science identity more for female students than for male students, while a negative value would indicate that the Minors program increased science identity more for male students than for female students. A non-significant coefficient, although not supporting the initial hypothesis, would be interesting since this would mean that the assumed benefit of the program is comparable across genders.
CHAPTER FOUR

HYPOTHESIS 2 ANALYSIS PLAN - MULTIPLE REGRESSION

Hypothesis group 2 requires the use of hierarchical multiple regression and dummy variables to test the effects of continuous, categorical, and interaction terms simultaneously. Multiple regression analysis will be denoted as MRC throughout this chapter, according to the conventions used by Cohen, Cohen, Aiken, and West (2003). Specifically, this chapter explores the rationale for using MRC in the present study. Discussion then moves on to the inclusion of categorical variables, interaction terms, and hierarchical MRC analyses. The majority of these discussions are specific to the study at hand. When necessary, relevant examples not tied to this study are used to explain additional concepts.

Use of MRC

Hypotheses 2b, 2c, 2d, and 2e involve testing both categorical (program type: Minors, Achievers, and Graduates) and continuous (desire to find a job, graduate college, recognition of achievements, number of visits to the Museum) independent variables in the same model, as well as two-way interaction terms between the two sets of variables. MRC is preferred in this situation primarily because it allows for the inclusion of both continuous and categorical independent variables in the same
predictive model. In fact, Fisher’s original ANOVA/ANCOVA calculations were only a methodological improvement over MRC because they were simpler to calculate (see Cohen, Cohen, Aiken, & West, 2003 for review). The complex calculations required for MRC are now easily performed by modern statistical applications (SPSS). With regards to interpretation of complex statistical results, MRC analyses produce intuitive measures of effect size, $R^2$, for the overall model and, when necessary, for each step in a hierarchical design.

**Important Assumptions**

The primary assumption underlying all of the following analyses is that the form of the relationship between the independent and dependent variables is linear. In a bivariate regression, this assumption is illustrated by assuming that all (or most) of the observations fall on a single line. In MRC, however, this line expands into a plane when there are two IVs, and a surface that cannot be represented when there are more than two independent variables. While this assumption ignores the possibility of curvilinear relationships, curvilinear models can be estimated with the use of exponential regression terms. Use of exponential regression terms were not considered for this project and will not be explored.

Two additional assumptions for MRC focus on the residuals between the actual values ($Y$) and the predicted values ($\hat{Y}$). The first of these is the assumption of homoscedasticity, or the constancy of variance of residuals. Homoscedasticity refers to how residuals are grouped around the regression line or surface. This assumption
assumes that all the residuals are at an approximately constant distance from the line/surface. If there is heteroscedasticity in the residuals (non-constant variance), then residuals are spread out more widely at certain points along the regression line/surface and grow more concentrated at other points. According to Cohen et al. (2003), a ratio of 10:1 or greater between the largest variance and the smallest indicates a possible violation of this assumption.

In addition to homoscedasticity of residuals, MRC also assumes normality of residuals, or normality within arrays. This normality assumption states that at any point along the regression line/surface, residuals are normally distributed around that line/surface. For example, the clustering of residuals around point A on a regression line should be more concentrated closer to the line and grow progressively more diffuse as the residuals get further away from the line. According to Cohen et al. (2003), violating the assumption of normality within arrays biases regression estimates when sample sizes are small.

**Use of Dummy Coding**

Dummy coding of categorical variables was used in testing both hypothesis group 1 and 2. All categorical variables were coded as 0 and 1, where 1 represents membership in a certain group and 0 represents non-membership. For example, gender was coded as 0 for females and 1 for males. The non-directional nature of hypothesis 2a allowed for either males or females to be coded 1. Using this coding scheme, a significant interaction term, either positive or negative, would provide support for
hypothesis 2a. Only a non-significant result would contradict hypothesis 2a. This “no difference” result would not be worthless, however, because it would provide evidence that the effects of program type are equal for males and females alike.

The program variable that distinguishes between Minors, Achievers, and Graduates requires two dummy-coded variables. Each dummy variable compares one program to a “reference program.” The choice of this reference program is not guided by statistical concerns. Rather, substantive factors often determine the most appropriate reference group. Hardy (1993) suggests three criteria for choosing an appropriate reference group: (1) the reference group should be useful for comparing all other groups to; (2) the reference group should be well defined; and (3) the reference group should not have a small sample size when compared to the other groups. The Minors group has the largest sample size and is the point at which all students begin their journey. For these reasons, Minors were chosen as the reference group for the present study. The following table illustrates how variables were dummy-coded:

<table>
<thead>
<tr>
<th>Program</th>
<th>Dummy Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( P_1 )</td>
</tr>
<tr>
<td>Minors</td>
<td>0</td>
</tr>
<tr>
<td>Achievers</td>
<td>1</td>
</tr>
<tr>
<td>Graduates</td>
<td>0</td>
</tr>
</tbody>
</table>
The three levels of the Program variable are represented by the two dummy-coded variables P1 and P2. Variable P1 compares Achievers to Minors, and P2 compares Graduates to Minors.

Employing dummy variables in a situation such as this presents a new wrinkle when interpreting regression coefficients. Instead of a single regression coefficient per independent variable, we now have two regression coefficients to interpret for a single independent variable. For example, the regression coefficients for P1 and P2 would represent the difference in science identity between Achievers and Minors (P1) and Graduates and Minors (P2), respectively. It is important to note that significance tests performed with dummy-coded variables only test the comparison between the reference group and the comparison group. To test differences between two groups, neither of which are the reference group, would require another set of dummy variables using a different reference group.

**Moderating Variables and Interaction Terms**

Moderating variables and interaction terms are of prime importance in this study. Hypothesis group 2 tests six moderating variables. These nonlinear effects can be summarized as testing the impact moderating variables have on the effect of program. Jaccard and Turrisi (2003) make the distinction between moderating variables and “focal independent variables.” The effect of focal independent variables on the dependent variable varies depending on the level of the moderating variable. In the current study, program type is the focal independent variable.
Incorporating interaction effects into MRC models allows exploration beyond additive effects to conditional relationships. A simple additive MRC model, like the one below, models the effect of $X$ as constant across all values of $Z$. All regression equations also contain an intercept term ($\alpha$) and an error term ($e$).

$$\hat{Y} = \alpha + \beta_1 X + \beta_2 Z + e$$ (6)

Indeed, this model would be mostly accurate when there is not a moderating effect of $Z$ on the relationship between $X$ and $Y$. However, when a moderating relationship is present, the effect of $X$ on $Y$ is not the same for all values of $Z$. This fact is key to understanding the tests of hypothesis group 2 in this study. For example, a model where the effect of $X$ (program type) on $Y$ (science identity) is constant across all values of $Z$ (recognition) would not support hypothesis 2b. However, if this relationship were dependent on $Z$ (students’ desire to work), then the hypothesis would be supported.

In order to include an interaction term in a MRC model, it is first necessary to do some data manipulation. In particular, it is necessary to compute a new variable to add to the dataset, something that is easily done using available statistical packages. According to the methods recommended by Cohen et al. (2003) and Jaccard and Turrisi (2003), two-way interaction terms are calculated by multiplying the values of the interacting independent variables for each observation. Prior to creation of the
interaction terms, all continuous (i.e., non-dummy coded variables) were centered along their means according to recommendations from Aiken and West (1991; Cohen et al., 2003) in order to ease the interpretation of significant interaction terms. A two way interaction between independent variable X and independent variable Z is represented (in equation 7 below) as the product of the two: XZ. A MRC model that includes such a two-way interaction term contains three regression coefficients:

\[ \hat{Y} = a + \beta_1 X + \beta_2 Z + \beta_3 XZ + e \]  

(7)

This is the simplest version of a MRC equation with an interaction term. Any time an interaction term is included in the model, each lower order variable also needs to be in the model. This means that when a two-way interaction term is in a model, both main effects need to be in the model as well. If there is a three-way interaction term, then all three main effects and two-way interactions also need to be in the model. This is necessary, because according to Cohen et al. (2003), an interaction term “only represents the interaction when all lower order terms have been partialled” (p. 290).

**Hierarchical Multiple Regression**

Hierarchical multiple regression refers to the sequential building of a full MRC model according to some logical progression. This logical progression is predetermined by researchers to create models specific to the needs of their research. For example, a researcher interested in the causal impact of several independent variables on a
dependent variable would want to build a model starting with those variables that came first before entering other independent variables. The models in this study were hierarchically structured into three steps. Main effects were entered in the first two steps followed by the two-way interaction term in the third.

Hierarchical procedures are useful when independent variables may have a causal impact on each other as well as the dependent variable. For example, gender is a variable that could have a causal impact on recognition, but not vice versa. If gender and recognition were two independent variables in a regression model predicting science identity, one would want to test gender before entering recognition because gender precedes it causally. This would provide an estimate of $R^2$ for gender only, independent of the influence of recognition. The difference in $R^2$ values between a model with only gender and a model with recognition would provide a meaningful estimate of $R^2$ for recognition independent of gender.

Unlike stepwise procedures that are available in statistical packages, hierarchical regression analyses are theory driven. Most stepwise procedures add independent variables to models on the basis of the variance each predictor explains. This creates the possibility of adding independent variables that seem to explain a significant amount of variance in one step, and then realizing in a later step, that a particular variable was confounded with another variable in the model.
Hierarchical Regression with Sets

Hierarchical regression can also be performed with sets of independent variables rather than with single independent variables at each step. This is particularly useful when estimating $R^2$ for variables that occur at the same point in time or when entering multiple dummy-coded variables. In the case of program type and the interaction terms, it was necessary to enter the two program-type variables in a single step and the two interaction variables in another step. Entering a different independent variable (program type, moderator, and interaction term) at each step of the regression analysis allowed SPSS to estimate and test the unique variance that each variable explained.
CHAPTER FIVE

METHODS

Instrument Development

In the present study, use of the term “science person” allowed participating students to bring their own conceptions to the table rather than adopting preconceived stereotypes of what constitutes a scientist. This approach also suggests an avenue for future research that was beyond the scope of the current study. It may be that stereotypes of scientists change over time, and that these changing stereotypes may influence identification with the field of science especially among those who decide to pursue education and careers in scientific fields.

The first item in the survey instrument (see Table 2 on the following page) taps into students’ self-identification as a “science person.” This item sets up four identities as separate but not mutually exclusive and contrasts with the method used by Nosek et al. (2002) described above. Rather than set up a dichotomy between two forms of identity, the scales below allow for a more differentiated conceptualization of identity.

Only scores on the “science person” scale were included in the science identity measure used in this study. This scale provides the measure of self-identification described by SIT.
Table 2: Survey Items to Measure “Science Person”

<table>
<thead>
<tr>
<th></th>
<th>Not Me</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A science person</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>A musical person</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>An artistic person</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>An athletic person</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

In addition to self-identification, it was necessary to assess how others perceive students as science people. Without access to parents, teachers, and friends, it was necessary to assess others’ perceptions based on respondents’ reports of what others think of them. The following three items were used to assess how important others in students’ lives (i.e., family, friends, and teachers) perceive them. Each item was scored on a 9 point agree/disagree scale (See Appendix A for a copy of the complete instrument).

1. My family thinks of me as a “science person”
2. My friends think of me as a “science person”
3. My teachers/instructors think of me as a “science person”

In addition to the self-identification and social aspects of identity, it was necessary to include measures of student interests, goals, and attitudes that characterize science people. In this way, an identity scale that ranges from “not a science person” all the way to “professional scientist” was constructed. Three modified items from Lent et al.’s (2005) measure of mathematical interest were incorporated into the science identity measure used in this study:
1. I am interested in working on a project involving scientific concepts.
2. Solving complicated scientific problems interests me.
3. I am not interested in reading websites, articles, or books about scientific issues. [reverse scored]

A comprehensive measure of ethnic identity, the Multigroup Ethnic Identity Measure or MEIM (Phinney, 1992), was also used to construct a broad measure of science identity. Phinney’s 15 item scale contains six items that were modified to measure science identity in the current study.

1. I spend my free time trying to find out more about science or scientific topics.
2. I am active in organizations or groups related to science.
3. I do not think a lot about how my life is affected by science. [reverse scored]
4. To learn more about science, I have often talked to others outside of school.
5. I have a lot of pride in the accomplishments of science.
6. I feel a strong attachment to scientific fields.

The other nine items of Phinney’s scale assume that participants already possess a form of ethnic identity. While this may be functional in the case of ethnic identity, science identity is substantively different in this regard as it is possible for students to lack a sense of science identity.

**Avoiding Ceiling and Floor Effects**

Use of “scientist” would likely create a ceiling effect where most students would have identity values near the lower end of the spectrum. On the other hand, the use of “science person” and the self-selected nature of the Minors and Achievers programs
combine to create the potential of a floor effect in the present study, through which scores might be restricted to the higher end of the measurement scale. The students who choose to participate in the Minors and Achievers programs likely have higher levels of science identity at enrollment than the average high school student. In order to prevent the floor effect, two additional items were included in the measure of science identity:

1. I am interested in pursuing a career in a scientific field.
2. Pursuing a degree in a scientific field in college or graduate school does not interest me. [reverse scored]

The final measure of science identity included 15-items that assessed self-identification (1 item), identification of important others (3 items), students’ interests related to science (9 items), and two items used to avoid a possible floor effect. A copy of the final survey instrument can be found in Appendix A.

**Reliability and Validity of Survey Instrument**

This measure of science identity developed for this study was tested for internal consistency among Minors ($\alpha = .93$), Achievers ($\alpha = .91$), and Graduates ($\alpha = .89$). The measure was also tested for convergent and divergent validity. Convergent validity for the science identity measure was assessed by correlating science identity with the reported number of science activities that students participate in or enjoy, using the following question:

Do you participate or enjoy the following: (select all that apply)

- After school science clubs.................................................1
- Science themed TV shows (CSI, Mythbusters, NOVA, Bones, etc.)..........................................................2
Identity scores for all unique survey respondents (respondents who were surveyed at least once in all program types) correlated positively and significantly with participation in and enjoyment of science activities \((r = .48, n = 135, p < .001)\). Science minors who completed both a pretest and a posttest demonstrated a similarly positive correlation with science activities on their pretest \((r = .42, n = 51, p = .002)\) and posttest \((r = .47, n = 71, p < .001)\).

Divergent validity of the science identity measure was assessed by correlating science identity with the three other forms self-identification used. If these items truly assessed unique and independent forms of identity, then their correlations with measures of other types of identity should be weak or nonexistent. Self-identification as a musical person \((r = -.03, n = 135, p = .76)\) and athletic person \((r = -.02, n = 135, p = .79)\) were not related to science identity. Self-identification as an artistic person showed a significant, but weak, positive correlation with science identity \((r = .17, n = 135, p = .05)\). In the Minors only sample, however, science identity did not have a significant correlation with any of these forms of identity: musical person \((r = .03, n = 59, p = .84)\), artistic person \((r = .09, n = 59, p = .50)\), and athletic person \((r = .03, n = 59, p = .83)\). This pattern of correlation supports the construct validity of the 15-item measure of science identity.
In addition to the measure of science identity, several possible moderating variables were assessed. One of which was the amount of time participating students spend at the Museum on their own time. When Minors and Achievers enroll in the program, they are given identification badges and allowed to enter the Museum when they wish. Indeed, the possession of an identification badge would serve as a useful cue for others as well as the student when considering group membership. Two questions regarding the use of these privileges were included in the final instrument.

1. I enjoy having access to the Museum outside of the Science Minors program.
2. Since you have been enrolled in Science Minors, how many times have you visited the Museum on your own time?

The importance of finding a job was also a concern for the Museum staff. It was thought that many students do not continue past the Minors program because they need to start working as soon as possible. This too will be assessed along with the importance of other goals like graduating high school, attending college, and being popular.

Although demographic factors such as age, gender, ethnicity and race were also recorded, not all of these variables were testable moderators. Gender was suited for testing and is explored in hypotheses 1a and 2a. Race, ethnicity, and age were too homogenous to allow meaningful statistical comparisons.

**Procedure**

The procedure for the present study was forced to adapt to changing and unplanned circumstances. The amount of time for data collection was ultimately
extended and informed consent was relaxed to informed passive consent. The section below describes the tasks and procedures that were planned during the design phase of the present study as well as detailing how the implementation of these tasks was altered over the course of the project.

Data collection was initially planned to occur between April and November 2011 during the spring and fall sessions. According to Museum staff, this would allow for two sessions of 30 Minors each to be surveyed twice (i.e., at pretest and posttest), as well as 60 parents of Minors, 30 Achievers, and 30 Graduates to be surveyed. Furthermore, Web-based surveys were the primary method of data collection upon inception of the study. Several unforeseen obstacles, as is characteristics of in applied research, however, required significant modifications and extension of data collection in order to achieve the desired sample size.

**Science Minors Surveys.** In April 2011 the author obtained 15 signed informed consent documents from the 15 parents that attended the Minors family information session prior to the first week of instruction. This was half the number of parents that were expected to attend. Email addresses for these students were provided by Museum staff and Web-based surveys were emailed to the students the following Monday, two days after the session. Two reminders were sent during the next two weeks and four students completed the survey. Unfortunately, data collection did not continue beyond two weeks due to the concern that too much instruction would have occurred, skewing the meaning of the pretest.
As it was clear that the Web-based method would not recruit the desired sample in time, a paper survey was used at posttest. During the final instructional session, when students were scheduled to complete other surveys for the Museum, the posttest was administered to 14 students who had been given parental consent, and were present on that day.

After the CPS summer vacation, when Minors is not in session, the Web-based method was dropped and a hard copy survey was used. Parental consent was revisited at this point, but was still considered essential by Museum staff. As in April, parental consent was sought during the parental information session in September 2011. During this session, however, parental consent and data collection was halted by a senior Museum staff member. This resulted in parental consent from only 13 parents. Even though data collection was halted during the parental information session, all 13 Minors who were given consent were able to complete the survey prior to the first instructional session during the following week. Posttest surveys were administered during the final Instructional session to the 12 students who were present on that day.

With the cooperation of the Museum, parental consent was relaxed to informed passive consent, prior to data collection in November 2011. Museum staff agreed that the study had been vetted to a satisfactory degree and informing parents prior to the study would satisfy their own IRB requirements. Parental information sheets (i.e., the original parental consent form sans signature line) describing the purpose of the study as well as parental and student rights, were mailed to parents of participating students,
along with other program related information, prior to the first weekend of instruction.

On the first weekend of instruction, survey packets and assent forms were distributed to participating Minors students. In this manner, 24 pretest surveys were collected in November 2011, and another 23 were collected in April 2012. Posttest surveys were conducted during the final day of both winter and spring sessions.

All surveys were conducted at the Museum in a classroom used by the Minors program. During each session, Minors who participated in the survey were surveyed in a single group.

**Achievers.** Data collection for Achievers began at the same time as the first session of Minors in April 2011. The original procedure described above (i.e., parental consent, Web-based survey) produced even fewer responses due to the need to send parental consent forms home with students and have them signed and returned. Between April and June 2011, four Achievers completed the Web-based survey. Parental consent remained the key issue until the passive consent process was adopted in November 2011. During the fall of 2011 only five Achievers were surveyed. Once the passive consent process was adopted, 35 Achievers took the survey in the spring of 2012.

Due to the considerable time from the start of the project (April 2011) and completion (June 2012), it was possible that students who were surveyed as Minors were also surveyed as Achievers. One Achievers survey was excluded from data collection as a potential duplicate based on reported birthdate, gender, and ethnicity. It
was necessary to exclude this survey to preserve the independence of the three groups (i.e., Minors, Achievers, and Graduates) during hypothesis testing.

**Graduates.** Graduates of the Achievers program were recruited during the summer of 2011, prior to the revised passive consent process. Fortunately, all 26 graduates were over the age of 18 and could provide their own informed consent. At the time, Graduates were participating in a computer training session related to their internships at the Museum. Surveys were conducted in small groups of 3 or 4 students at a time, rather than in a single large group, in a separate room from the computer training session.

**Participants**

Between April 2011 and June 2012, 136 surveys were collected from Minors, 44 from Achievers, and 26 from Graduates. Of the 136 Minors surveys completed, 65 (47.79%) were pretests and 71 (52.21%) were posttests. Fifty-nine pretests and posttests were matched on the basis of respondents’ birthdate, gender, and ethnicity.

Female students made up the majority of survey participants at each program level, see Table 3 below. Chi-square testing determined that the proportion of male and female students surveyed were the same for each program level., $\chi^2 (2, N = 134) = 0.70$, $p = 0.71$, Cramer’s $V = .07$. 
Table 3: Gender of Survey Respondents

<table>
<thead>
<tr>
<th>Program</th>
<th>Gender</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Minors</td>
<td>26</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>40.63%</td>
<td>59.38%</td>
</tr>
<tr>
<td>Achievers</td>
<td>21</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>47.73%</td>
<td>52.27%</td>
</tr>
<tr>
<td>Graduates</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>38.46%</td>
<td>61.54%</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>42.53%</td>
<td>57.46%</td>
</tr>
</tbody>
</table>

On average, students that participated in the surveys were between the ages of 13 and 19 with an average age of 16.79 years (SD = 1.76, See Table 4). As expected, students’ ages differed significantly between the program types, $F(2, 125) = 101.73, p < .001, \eta^2 = .62$. Post hoc analyses using the Scheffé post hoc criterion for significance demonstrated that the average age of Minors ($M = 15.60, SD = 1.12$) was significantly lower than both Achievers ($M = 17.00, SD = 1.11$) and Graduates ($M = 19.24, SD = 1.02$), the average age of Achievers was older than Minors but younger than Graduates, and the average age of Graduates was older than both Minors and Achievers.

Table 4: Age of Survey Respondents

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minors</td>
<td>61</td>
<td>15.60</td>
<td>1.12</td>
</tr>
<tr>
<td>Achievers</td>
<td>41</td>
<td>17.00</td>
<td>1.11</td>
</tr>
<tr>
<td>Grads</td>
<td>26</td>
<td>19.24</td>
<td>1.02</td>
</tr>
<tr>
<td>Total</td>
<td>128</td>
<td>16.79</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Respondents were asked to select any and all racial and ethnic categories according the U.S. Department of Education’s 2007 guidelines. In Table 5 each column does not total to 100% since each respondent was able to select as many categories as
necessary. Testing the ethnic makeup of each sample is problematic in that the data violates the key assumption of independence of observations in Chi-square testing. Reclassifying students into a more generic white/non-white distinction also proved problematic. Classifying students who only selected “white” and no other category resulted in too few students in several cells. Classifying students who selected “white” at all resulted in a viable Chi-square analysis that demonstrated no differences between the three program levels, $\chi^2(2, N = 135) = 0.35, p = 0.84, \text{ Cramer's } V = .05$. This tactic is conceptually problematic in the sense that the distinction between the white/non-white groups is unclear.

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Minors</th>
<th>Achievers</th>
<th>Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic/Latino</td>
<td>15</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Asian</td>
<td>8</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Black or African American Native Hawaiian or Other Pacific Islander</td>
<td>37</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>White</td>
<td>14</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>44</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 5: Race and Ethnicity of Survey Respondents

After the spring of 2012, of the estimated 120 students that participated in the Minors program over that time, a total of 76 students had been surveyed for a response rate of 63%. Fifty-nine students completed both pre and posttests for a matched response rate of 50%. For a captive audience, this low response-rate was unanticipated.
The HLM and repeated-measures analyses used to test hypothesis group 1 are based on the 59 students. Tests used for hypothesis group 2 are based on the 65 surveys of Minors students who completed the pretest, 44 Achievers, and 26 Graduates.

**Attrition.** Due to the unique challenges described above, anticipated issues related to attrition were not encountered. During the design stages, it was believe that attrition from the Minors program between pre- and post-test would result in low numbers of matched pre- and post-tests. In fact, the opposite was the case. Due to the challenges of implementing the pre-test surveys, post-test surveys were easier to obtain, resulting in more students completing a post-test survey. While it still may be the case that matched pairs of surveys were obtained from a qualitatively different group of students, it is difficult to determine if this was the case, and if so how responders were different from non-responders.

**Qualitative Procedure**

Focus groups were used in the present study to account for the lack of an appropriate comparison group (i.e., high school students who did not participate in the Museum’s programs). A comparison group of high school students would have provided insight into the causal impact of the Museum’s programming. Without such a group, it was necessary to ask participating students about the impact they perceived the Minors and Achievers programs may or may not have had.

Two focus groups of four students each were conducted in the afternoon of Saturday, October 8<sup>th</sup>, 2011. While the ideal size of a focus group is between five and
eight participants (Krueger, Casey, & Kumar, 2009), convenience sampling limited the number of students that could and wanted to participate.

Achievers were recruited by Museum staff from those students that had been given parental consent or were 18 years or older and could provide their own consent. Four male students and four female students volunteered to participate in the groups. Each focus group lasted for approximately 1 hour and was conducted in one of the classrooms used by the Achievers program. Groups were conducted after surveys had been collected from Achievers so as to avoid any confounding effects on the survey results.

Gender effects were of particular concern with respect to focus group discussions. It was believed that including male and female students in the same focus group might stifle discussion on the part of female students due to the stereotypically male nature of scientific pursuits. For this reason, one group was made up of the four female volunteers while the other consisted of the four male volunteers.

A third focus group was conducted on Saturday, March 3rd, 2012 with eight Achievers, four male and four female. Due to scheduling constraints, the Museum was unable to provide time or space for 2.5 hours worth of focus groups. Instead, a combined gender group was conducted during the Achievers’ lunch break and lunch was provided by the Museum. All Achievers were asked if they would like to participate in the group and the first eight were allowed to participate. At this point in the study, parental consent was no longer required and parental information sheets had been
distributed to all parents of participating students. Achievers were also given the option of to participate or not.

The unanticipated scheduling limitations that resulted in this third combined-gender group created the unintended benefit of testing the assumption that a combined gender group would stifle discussion on topics related to gender. Comparisons between the single-gender and combined-gender groups provided some insight into the validity of this assumption.

One-on-one interviews were considered for this project, but focus groups had three distinct advantages over individual interviews (see Kreuger, Casey, & Kumar, 2009 for a review). First, focus groups provide a comfortable environment where students are among peers in which students can share their opinions openly and provide the opportunity for interactions among participants. The true advantage of focus groups is that they allow for interactions between individuals that provide opportunities for additional discussion and more spontaneous responses. Focus groups were also convenient given for the Museum’s needs. Achievers had limited flexibility during their time at the Museum and in depth individual interviews with the same number of students would not have been possible given time constraints.

Focus group questions were similar to those used in the survey instrument, but stressed the development of science identity during the program. Questions probing gender differences in science identity were also included. In the combined group,
gender questions were specifically directed to female students first and then male students. A copy of the focus group script can be found in Appendix B.
CHAPTER SIX

QUANTITATIVE RESULTS

Results of tests for hypothesis group 1 are presented first and include both unstandardized (B) coefficients, for ease of interpretation, and standardized (β) coefficients, to describe effect sizes. Since the HLM software only calculates unstandardized coefficients, standardized coefficients were calculated using the formula below (Hox, 2010).

\[
\beta = B \times \frac{SD_x}{SD_y}
\]  

(8)

In this chapter results are presented that test hypothesis groups 1 and 2. It is important to note that the sample size for the present study is relatively small. Some researchers argue that between 50 and 100 groups with between five and ten cases per group are necessary for sufficient power in HLM analyses (Hox, 2010). For example, research by Dziak, Nahum-Shani, and Collins (2012) demonstrated that HLM tests with five groups of 50 individuals would have approximately 65% power to find a main effect and about 22% power to detect an interaction. The power in the present study is considerably less considering the two group (i.e., time points) design with 59 participants at each time point.
Results from the ANOVA and hierarchical multiple regression (not to be confused with HLM) analyses used to test hypothesis group 2 also contain measures of effect size. Partial eta-squared ($\eta^2$) is used for effects in factorial ANOVA analyses. Cohen’s (1988) conventions for effect size can be used to interpret the magnitude of $\eta^2$ (small, $\eta^2 \approx 0.01$; medium, $\eta^2 \approx 0.06$, large, $\eta^2 \approx 0.14$). The 135 surveys collected from Minors at pretest, Achievers, and Graduates provided 74.11% power to detect a moderate effect size ($\eta^2 = .06$) for the main effect of program type in a one-way ANOVA. This sample size ($N = 135$) provided over 80% power (82.98%) to detect a moderate main effect ($\eta^2 = .06$) of a two level variables, and 74.07% power to detect moderate main effects of a three level variable and the interaction term in a 2x3 factorial ANOVA.

The multiple regression analyses in the present study employed $R^2$ as a measure of effect size and use Cohen’s (1992) conventions for small ($R^2 = 0.01$), medium ($R^2 = 0.09$) and large ($R^2 = 0.25$) effect sizes. The sample size of 135 for hypothesis 2 provided the five predictor models used with 80% power to detect a small to moderate $R^2$ of .081.

**Hypothesis 1: Development of Science Identity**

Testing hypothesis 1 using HLM required the use of an unconditional model where no level-2 variables are specified. In this case, the HLM program calculated estimates for the average initial identity-rating ($\beta_{00}$) and the average growth-rate for all students ($\beta_{10}$). Furthermore, the unconditional model also estimates the amount of variance associated with each $\beta$. These estimates provide information as to whether there is any variance for level-2 variables to explain.
The unconditional HLM model confirms hypothesis 1. There is a significant positive impact of the Minors program on a student’s science identity, $\beta_{10} = 0.11; t(58) = 2.56, p = .013$. In addition, this model estimates that the average student entered the Minors program with a 93.61 science identity rating. Given that scores on the science identity scale range from 15 to 135, the average of 93.61 is greater than the midpoint of the scale (which is 75). Specifically, the average score of 93.61 represents 65.5% of the highest achievable score (i.e., the 65.50th percentile) on the identity scale. At posttest students averaged 98.97 (69.98th percentile) on the science identity scale.

Estimates of student-level variation demonstrate that students vary significantly in their initial level of science identity ($r_{ij} = 577.45, \chi^2 = 33550.20, p < .001$) and mean growth rate in science identity from pretest to posttest ($r_{ij} = 261.45, \chi^2 = 7639.97, p < .001$). Significant student level variation, combined with the observed average science identity score, provide evidence that the identity measure used was at least successful in avoiding a floor effect. Students who enrolled in Science Minors were not “maxing out” the science identity scale. Significant student-level variation in the mean growth-rate ($r_{ij}$) also provides justification for further investigation of level-2 variables that hypothesized to moderate the observed variation in growth rates.
Table 6: Hypothesis 1 - Unconditional Model

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean initial science identity, ( \beta_{00} )</td>
<td>93.61</td>
<td>3.10</td>
<td>30.15</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Mean growth rate, ( \beta_{10} )</td>
<td>5.36</td>
<td>0.11</td>
<td>2.10</td>
<td>0.013</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Random Effect</th>
<th>Variance Component</th>
<th>df</th>
<th>( \chi^2 )</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial science identity, ( r_{0j} )</td>
<td>577.45</td>
<td>58</td>
<td>33,550.20</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Growth rate, ( r_{ij} )</td>
<td>261.45</td>
<td>58</td>
<td>7639.97</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

**Hypothesis 1a: Gender as a Moderator of Growth in Science Identity**

Hypothesis 1a made the non-directional hypothesis that male and female students would react differently to the Minors program. To test hypothesis 1a, the HLM model tested above requires the incorporation of gender at level-2. The level-1 model remains the same as above \( Y_{ti} = \pi_{0i} + \pi_{1i} PrePost_{1i} + e_{ti} \). The level two equations, however, incorporate a single student-level variable for each test:

\[
\begin{align*}
\pi_{0i} &= \beta_{00} + \beta_{01}(Gender)_i + r_{0i} \\
\pi_{1i} &= \beta_{10} + \beta_{11}(Gender)_i + r_{1i}
\end{align*}
\] (9)

Student gender was dummy-coded so that 0 represented males and 1 represents females. The magnitude and significance of \( \beta_{11} \) will assess the hypothesized moderating impact gender has on the relationship between Science Minors and the rate at which students develop science identity over time.
As Table 7 demonstrates, contrary to the a priori hypothesis, students’ gender did not have a significant relationship with either initial status ($\beta_{01} = -0.070; t(57) = -0.81, p = 0.42$) or change in science identity from pretest to posttest ($\beta_{11} = -0.004; t(57) = -0.041, p = .97$).

These non-significant results provide evidence for two meaningful conclusions. First, science identity did not significantly differ between boys and girls upon entering the Minors program. Second, the change in science identity from pretest to posttest was equivalent for boys and girls.

<table>
<thead>
<tr>
<th>Table 7: Hypothesis 1a – Gender Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Effect</td>
</tr>
<tr>
<td>Model for initial science identity, $\pi_{0i}$</td>
</tr>
<tr>
<td>INTERCEPT, $\beta_{00}$</td>
</tr>
<tr>
<td>Gender, $\beta_{01}$</td>
</tr>
<tr>
<td>Model for growth rate, $\pi_{1i}$</td>
</tr>
<tr>
<td>INTERCEPT, $\beta_{10}$</td>
</tr>
<tr>
<td>Gender, $\beta_{11}$</td>
</tr>
</tbody>
</table>

**Hypothesis 1b: Desire to Work as a Moderator of Growth in Science Identity**

A priori hypothesis 1b predicted that the development of science identity would be inhibited by a student’s desire to find a job as soon as possible. Upon enrolling in the Minors program, students had a relatively high desire to find a job as soon as possible ($M = 6.80$), but also showed ample variability in their responses ($SD = 2.26$, range = 8).
Hypothesis 1b was confirmed, $\beta_{11} = -0.30$; $t(57) = -2.5$, $p = 0.02$ (See Table 8), indicating that a student’s desire to find a job as soon as possible was a negative predictor of the rate at which their level of science identity changed over time.

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>$SE$</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model for initial science identity, $\pi_{0i}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERCEPT, $\beta_{00}$</td>
<td>93.6</td>
<td>3.1</td>
<td>30.5</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Desire to work, $\beta_{01}$</td>
<td>-1.6</td>
<td>-0.15</td>
<td>1.5</td>
<td>0.29</td>
</tr>
<tr>
<td>Model for growth rate, $\pi_{1i}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERCEPT, $\beta_{10}$</td>
<td>5.4</td>
<td>2.0</td>
<td>2.7</td>
<td>0.01</td>
</tr>
<tr>
<td>Desire to work, $\beta_{11}$</td>
<td>-2.0</td>
<td>-0.30</td>
<td>0.8</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**Hypothesis 1c: Desire to Graduate College as a Moderator of Growth in Science Identity**

In contrast to hypothesis 1b, hypothesis 1c predicted that a student’s desire to graduate college would increase their rate of growth in science identity from pretest to posttest. Contrary to this prediction, hypothesis 1c was not supported, $\beta_{11} = -0.05$; $t(57) = -0.3$, $p = 0.75$ (See Table 9).

This null finding may be a result of the distribution in students’ desire to graduate college. Univariate analysis revealed that all responding students scored between 7 and 9 on the 9-point scale in response to the item, “How important is the following to you: Graduating college” ($M = 8.80$, $SD = 0.45$). The lack of variability in this item made it unlikely that it would explain any variability in the HLM model. All students who enrolled in Science Minors saw similar increases in science identity regardless of what little differences existed in their strong desire to graduate college.
### Table 9: Hypothesis 1c – Desire to Graduate College

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEPT, $\beta_{00}$</td>
<td>93.61</td>
<td>3.10</td>
<td>30.21</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Desire to graduate college, $\beta_{01}$</td>
<td>3.25</td>
<td>0.06</td>
<td>4.30</td>
<td>0.76</td>
</tr>
<tr>
<td>INTERCEPT, $\beta_{10}$</td>
<td>5.4</td>
<td>2.09</td>
<td>2.56</td>
<td>0.01</td>
</tr>
<tr>
<td>Desire to graduate college, $\beta_{11}$</td>
<td>-1.80</td>
<td>-0.05</td>
<td>5.61</td>
<td>-0.32</td>
</tr>
</tbody>
</table>

**Hypothesis 1d: Recognition of Important Others as a Moderator of Growth in Science Identity**

Recognition of students’ work and accomplishments by family, friends, and teachers in science was hypothesized to have a positive association with the rate of growth in science identity between pretest and posttest. Fortunately, recognition did not show the same ceiling effect as desire to graduate college did. Furthermore, recognition remained stable over the course of the program, $t(58) = 0.097, p = .92$, Cohen’s $d = 0.013$.

Contrary to the a priori hypothesis, students’ ratings of how their parents, teachers, and friends recognized their work and/or accomplishments in science was unrelated to the rate at which science identity developed over time, $\beta_{11} = -0.23, t(57) = -1.4, p = .16$ (see Table 10). This pattern of results is consistent with the conclusion that the Minors program benefitted all students who enrolled in the program, regardless of the degree to which important others recognized their accomplishments in science.

Recognition of students’ work and accomplishments had an unanticipated positive impact on students’ level of science identity upon enrollment into Science
Minors, $\beta_{01} = 0.74$; $t(57) = 6.0$, $p < .001$. Recognition was centered around its grand mean, such that the student with the average amount of recognition from important others ($M = 19.81$, $SD = 3.78$) entered the program with an initial science identity score of 93.6. Thus, each one-point increase on the recognition scale (range: 3–36) would increase initial science identity by 3.7 points.

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>$SE$</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model for initial science identity, $\pi_{0i}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERCEPT, $\beta_{00}$</td>
<td>93.6</td>
<td>2.5</td>
<td>37.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Recognition, $\beta_{01}$</td>
<td>3.7</td>
<td>0.6</td>
<td>6.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Model for growth rate, $\pi_{1i}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERCEPT, $\beta_{10}$</td>
<td>5.4</td>
<td>2.1</td>
<td>2.6</td>
<td>0.01</td>
</tr>
<tr>
<td>Recognition, $\beta_{11}$</td>
<td>-0.8</td>
<td>0.5</td>
<td>-1.4</td>
<td>0.16</td>
</tr>
</tbody>
</table>

**Hypothesis 1e: Visits to the Museum as a Moderator of Growth in Science Identity**

Hypothesis 1e tested the impact of an important aspect of the Minors program, the ability to visit the Museum for free outside of program hours. It was hypothesized that the number of reported visits to the museum would be associated with a greater increase in science identity between the pretest and posttest. On average, students reported making 2.49 trips to the Museum on their own time since enrolling in the Science Minors program ($SD = 3.39$). Thirty three students (55.93%) made between 1 and 3 trips and two students (3.39%) reported making over 10 trips on their own time.

As Table 11 illustrates, hypothesis 1e was not supported. The rate at which science identity developed over time was unrelated to the number of extra trips to the
Museum, β_{11} = 0.03; t(57) = 0.7, p = 0.5. Contrary to hypothesis 1e, growth in science identity is constant regardless of students’ use of the Museum outside of the program.

**Table 11: Hypothesis 1e – Visiting the Museum**

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model for initial science identity, π_{0i}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERCEPT, β_{00}</td>
<td>94.0</td>
<td>3.0</td>
<td>30.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Visits to Museum, β_{01}</td>
<td>-0.9</td>
<td>-0.06</td>
<td>-0.9</td>
<td>0.36</td>
</tr>
<tr>
<td>Model for growth rate, π_{1i}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERCEPT, β_{10}</td>
<td>5.2</td>
<td>2.2</td>
<td>2.4</td>
<td>0.02</td>
</tr>
<tr>
<td>Visits to Museum, β_{11}</td>
<td>0.3</td>
<td>0.03</td>
<td>0.7</td>
<td>0.50</td>
</tr>
</tbody>
</table>

**Hypothesis 1f: Science Mentors as a Moderator of Growth in Science Identity**

Students with science mentors (62.71%), were predicted to show more science identity growth during the Minors program. Table 12 demonstrates that this hypothesis was not supported in the present study.

**Table 12: Hypothesis 1f – Science Mentors**

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model for initial science identity, π_{0i}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERCEPT, β_{00}</td>
<td>92.0</td>
<td>4.8</td>
<td>19.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Science Mentor, β_{01}</td>
<td>2.2</td>
<td>0.03</td>
<td>6.2</td>
<td>0.72</td>
</tr>
<tr>
<td>Model for growth rate, π_{1i}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERCEPT, β_{10}</td>
<td>1.4</td>
<td>4.6</td>
<td>0.3</td>
<td>0.76</td>
</tr>
<tr>
<td>Science Mentor, β_{11}</td>
<td>5.7</td>
<td>0.07</td>
<td>5.1</td>
<td>0.27</td>
</tr>
</tbody>
</table>

**Hypothesis 2: Minors, Achievers, and Graduates**

In addition to the pretest-posttest design employed in hypothesis group 1, hypothesis group 2 focused on different groups of students as they progressed through
the track started in Science Minors. Science Minors can advance to the Science Achievers program, and Graduates of the Achievers program can pursue internships at the Museum. These three groups (Minors, Achievers, and Graduates) were hypothesized to have escalating levels of science identity (Minors < Achievers < Graduates). Contrary to this prediction, however, a one-way ANOVA revealed no significant differences among any of the three groups, \( F(2, 132) = 0.45, p = 0.64, \eta^2 = .007 \).

<table>
<thead>
<tr>
<th>Table 13: Science Identity by Program Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Science Minors</td>
</tr>
<tr>
<td>Science Achievers</td>
</tr>
<tr>
<td>Graduates</td>
</tr>
</tbody>
</table>

The patterns of means displayed in Table 13, while not significantly different from one another, are in fact in the opposite direction from what was hypothesized. This non-significant trend may be a symptom of the Dunning-Kruger effect (Kruger & Dunning, 1999). The Dunning-Kruger effect was expressed best by Charles Darwin in *The Descent of Man* (1871), “ignorance more frequently begets confidence than does knowledge.” In the present study, it may have been the case that students in the Minors program considered themselves to be science people. More experienced students, however, may have a different perspective and have seen what a true science person looks like. This interpretation is consistent with the pattern of means observed in Table 12.
**Hypothesis 2a: Gender and Level of Science Identity**

While testing of hypothesis 2 demonstrated that there was no main effect of program type on science identity, it is still possible to test the main and interaction effects of several moderating variables. Hypothesis 2a predicted that male students, compared to female students, would demonstrate larger increases in science identity over the course of the program. It is important to note that while female students made up the majority of survey respondents in each program (i.e., Minors, Achievers, and Graduates), there was not a significant difference in the proportion of male and female respondents between programs, $\chi^2 (2, N = 134) = 0.70, p = 0.71$, Cramer’s $V = 0.072$.

Contrary to hypothesis 2a, a 2 (gender) x 3 (program) between-groups ANOVA found a non-significant main effect of gender, $F(1, 127) = 0.74, p = 0.39, \eta^2 = 0.006$, and a non-significant gender x program type interaction, $F(2, 127) = 2.40, p = 0.095, \eta^2 = 0.036$.

Hypotheses 2b-2d all concern the moderating effect of continuous variables (desire to work, desire to graduate college, and recognition as a science person by important others, respectively). Hierarchical multiple regression analyses using dummy-coded variables to represent program type were used to test the main effects and interaction terms for each of these three hypotheses.
Hypothesis 2b: Students’ Desire to Work and Level of Science Identity

Hypothesis 2b predicted that a student’s higher desire to work would predict lower levels of science identity. Contrary to the hypothesis, however, desire to work was unrelated to science identity, $\Delta R^2 = .012, F(2, 129) = 0.81, p = 0.45$ (See Table 14).

Hypothesis 2c: Desire to Graduate College and Level of Science Identity

Contrary to hypothesis 2c, students’ desire to graduate college had no relationship their level of science identity when collapsing across program levels, $\Delta R^2 = 0.005, F(2, 129) = 0.33, p = 0.72$ (see Table 15). However, as was the case with Minors students in testing hypothesis 1c, students’ desire to graduate was very high and did not vary ($M = 8.73, SD = 0.74$, maximum possible score = 9). Thus it is not surprising that the desire to graduate college was unrelated to levels of science identity, because there was too little variability in the desire to attend college to permit a valid test of hypothesis 2c.
### Table 14: Summary of Hierarchical Regression Analysis for Hypothesis 2b (N = 135)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE B</td>
<td>β</td>
<td>B</td>
<td>SE B</td>
<td>β</td>
<td>B</td>
</tr>
<tr>
<td>Desire to Work</td>
<td>-0.77</td>
<td>0.94</td>
<td>-0.07</td>
<td>-0.65</td>
<td>0.97</td>
<td>-0.60</td>
<td>-1.61</td>
</tr>
<tr>
<td>Achiever Code</td>
<td>-0.66</td>
<td>4.42</td>
<td>-0.01</td>
<td>-0.97</td>
<td>4.45</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>Graduate Code</td>
<td>-4.27</td>
<td>5.25</td>
<td>-0.08</td>
<td>-3.97</td>
<td>5.33</td>
<td>-0.07</td>
<td></td>
</tr>
<tr>
<td>Achiever x Work</td>
<td>2.89</td>
<td>2.28</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate x Work</td>
<td>1.23</td>
<td>2.72</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔR²</td>
<td>0.005</td>
<td></td>
<td></td>
<td>0.005</td>
<td></td>
<td></td>
<td>0.012</td>
</tr>
<tr>
<td>F (df) for ΔR²</td>
<td>0.67 (1, 133)</td>
<td>0.34 (2, 131)</td>
<td>0.81 (2, 129)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *p < .05.  **p < .01.

### Table 15: Summary of Hierarchical Regression Analysis for Hypothesis 2c (N = 135)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE B</td>
<td>β</td>
<td>B</td>
<td>SE B</td>
<td>β</td>
<td>B</td>
</tr>
<tr>
<td>Desire to Graduate</td>
<td>4.54</td>
<td>2.57</td>
<td>0.14</td>
<td>5.09</td>
<td>2.66</td>
<td>.17</td>
<td>3.68</td>
</tr>
<tr>
<td>Achiever Code</td>
<td>.44</td>
<td>4.38</td>
<td>.01</td>
<td>0.49</td>
<td>4.40</td>
<td>0.01</td>
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</tr>
<tr>
<td>Graduate Code</td>
<td>-5.70</td>
<td>5.12</td>
<td>-.10</td>
<td>-1.84</td>
<td>7.33</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>Achiever x Desire to Grad</td>
<td>2.02</td>
<td>6.95</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate x Desire to Grad</td>
<td>-15.68</td>
<td>23.41</td>
<td>-0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔR²</td>
<td>0.023</td>
<td></td>
<td></td>
<td>0.011</td>
<td></td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>F (df) for ΔR²</td>
<td>3.12 (1, 133)</td>
<td>0.73 (2, 131)</td>
<td>0.33 (2, 129)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *p < .05.  **p < .01.
Hypothesis 2d: Recognition and Level of Science Identity

Supporting hypothesis 2d, the extent to which important others (parents, teachers and friends) recognized students’ scientific work and achievements had a significant positive relationship with level of science identity, $\Delta R^2 = 0.28, F(1, 132) = 49.99, p < 0.001$ (see Table 16). Contrary to hypothesis 2d, this effect was constant across all levels of the program, as the addition of interaction terms in Model 3 did not produce a significant increase in explained variance, $\Delta R^2 = 0.02, F(2, 128) = 2.0, p = 0.13$.

Hypothesis 2e: Time Spent at Museum and Level of Science Identity

Time spent at the Museum was predicted to have a moderating relationship on the relationship between program type and science identity. Students in Achievers and Graduates would spend more time at the Museum on their own time, and the more time a student spent at the Museum, the more they would identify as science people.

Respondents were asked to note how many times they had visited the Museum on their own since enrolling in the program. Unfortunately, this was not an appropriate question for some Achievers and most Graduates. Many of Achievers and Graduates interpreted this open-ended question to include internships and work that they performed at the Museum. For this reason, responses to this question ranged from zero trips to twice a day for three years. Distinguishing between trips for work and trips for personal enjoyment was not possible for these two groups. And even if it had been possible to distinguish between respondents who provided work-related trips and those
who provided leisure-related trips, elimination of the former respondents would have reduced an already small sample size.

Fortunately, a similar question that asked students to evaluate their enjoyment of visiting the Museum on their own time was included in the survey and could be used as a proxy variable for testing hypothesis 2e. Contrary to hypothesis 2e, students’ enjoyment of visiting the Museum on their own time was unrelated to levels of science identity, $\Delta R^2 = 0.001, F(2, 128) = 0.050, p = 0.95$ (see Table 17). However, the nonsignificant enjoyment x program level demonstrated that enjoyment with visiting the Museum had a positive relationship with science identity regardless of program level (i.e., Minors, Achievers, Graduates), $\Delta R^2 = 0.089, F(1, 132) = 12.86, p < 0.001$. 
Table 16: Summary of Hierarchical Regression Analysis for Hypothesis 2d  
(N = 135)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE B</td>
<td>β</td>
</tr>
<tr>
<td>Recognition</td>
<td>2.62</td>
<td>0.37</td>
<td>0.52**</td>
</tr>
<tr>
<td>Achiever Code</td>
<td>5.18</td>
<td>3.76</td>
<td>0.11</td>
</tr>
<tr>
<td>Graduate Code</td>
<td>-2.24</td>
<td>4.36</td>
<td>-0.04</td>
</tr>
<tr>
<td>Achiever x Recognition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate x Recognition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔR²</td>
<td>0.28</td>
<td>0.016</td>
<td>0.022</td>
</tr>
<tr>
<td>F (df) for ΔR²</td>
<td>49.99 (1, 132)**</td>
<td>1.51 (2, 130)</td>
<td>2.04 (2, 128)</td>
</tr>
</tbody>
</table>

*p < .05.  **p < .01.

Table 17: Summary of Hierarchical Regression Analysis for Hypothesis 2e  
(N = 135)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE B</td>
<td>β</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>4.4</td>
<td>1.2</td>
<td>0.3**</td>
</tr>
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<tr>
<td>ΔR²</td>
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<td>0.012</td>
<td>0.001</td>
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<tr>
<td>F (df) for ΔR²</td>
<td>12.86 (1, 132)**</td>
<td>0.86 (2, 130)</td>
<td>0.050 (2, 128)</td>
</tr>
</tbody>
</table>

*p < .05.  **p < .01.
**Hypothesis 2f: Science Mentor and Level of Science Identity**

Hypothesis 2f predicted that students’ who considered someone to be their “science mentor” would report higher levels of science identity, compared to students who did not report having a science mentor. Confirming hypothesis 2f, a 2 (presence versus absence of science mentor) x 3 (program) between-subjects ANOVA found a significant positive main effect of having a science mentor, $F(1, 117) = 5.19, p = 0.025$, $\eta^2 = 0.042$, when collapsing across program levels. Students who indicated they had a “science mentor” ($M = 95.94, SD = 22.78$) had significantly higher levels of science identity than students who did not report having a science mentor ($M = 86.14, SD = 19.63$). The science mentor x program type interaction, however, was non-significant, $F(2, 117) = 0.34, p = 0.71$, $\eta^2 = 0.006$. 
CHAPTER SEVEN

POST HOC ANALYSES

Further analysis of the four types of identity explored in the survey revealed significant differences between identity types, as well as a significant interaction between type of identity and gender. The four types of identity explored in the survey were science person, musical person, artistic person, and athletic person (see Table 2). While no hypotheses were made related to the differences among these four simple measures of identity, exploring them may provide Museum staff with a deeper understanding of the population they are serving.

A 4 (identity type) x 3 (program type) x 2 (gender) mixed-model ANOVA revealed a significant main effect of identity type, $F(3, 381) = 2.91, p = .034, \eta^2 = .022$, and a significant identity type x gender interaction, $F(3, 381) = 4.61, p = .004, \eta^2 = .035$. No significant main effect of either program type or gender was observed. Follow-up analyses using the Bonferroni post-hoc criterion for significance demonstrated that the average rating for “a science person” ($M = 6.60, SD = 1.67$) was significantly higher than ratings for “a musical person” ($M = 5.94, SD = 2.23$) and “an artistic person” ($M = 5.97, SD = 2.14$). Student ratings of “an athletic person” were not significantly from the other three categories.
As seen in Table 18, the pattern of means for all students, regardless of gender, first demonstrates that students rated themselves above the scale average (5 on the 1-9 scale) on all four forms of identity with “science person” rated the highest ($M = 6.64$, $SD = 1.63$).

| Table 18: Average Self-Identification Values by Gender |
|---------------------------------------------|----------------|----------------|----------------|
| Science Person                             | Musical Person | Artistic person | Athletic person |
| Male (N = 57)                              | 7.04 (1.64)    | 5.47 (2.14)    | 5.77 (2.02)    | 6.63 (2.55)    |
| Female (N = 76)                            | 6.34 (1.56)    | 6.30 (2.14)    | 6.24 (2.04)    | 5.59 (2.54)    |
| All (N = 133)                              | 6.64 (1.63)    | 5.54 (2.17)    | 6.04 (2.04)    | 6.04 (2.59)    |

The significant two-way interaction term demonstrates a few interesting possibilities. First, it appears that the largest difference in self-identification ratings between male and female students was for the category of “athletic person,” with females scoring one point lower than males on average. Male students also scored higher than female students on the “science person” item, but lower on both the musical and artistic scales.

Female students that participated in the present study, may have had more stable or differentiated identities. The average difference between the highest rated identity ($M = 6.34$) and the lowest rated identity ($M = 5.56$) for females is half the difference between the highest and lowest rated identities for males (0.75 and 1.56 respectively). Each of these single-item measures of identity is essentially unidimensional and crude. Future research may demonstrate, however, that there are
true gender differences in terms of differentiation of identity among the general population of high-school aged students.
CHAPTER EIGHT

QUALITATIVE RESULTS

In the absence of a true comparison group, three focus groups were conducted to serve two primary purposes: (1) to determine how these students in the Achievers program differ from students who do not enroll in the program and (2) to explore how the Achievers program has impacted them. Two focus groups of four Achievers students were conducted on October 8, 2011. One group consisted of four male Achievers and the other four female Achievers. A third group of eight Achievers (four male and four female) was conducted on March 17, 2012. The October, 2011 groups were between 45 minutes and 1 hour each and the March, 2012 group was approximately 90 minutes. Each group was audio recorded and transcribed.

Conversations during the focus groups also pointed towards the idea that students who enroll in the Minors program enjoy science somewhat more at the start, compared to students who do not enroll in the program. Although this was not universally the case, given that many students stated emphatically they did not like science before enrolling in Minors. Conversations regarding the Museum’s impact on students’ identity provided a much richer body of evidence. Students described ways in which programs enhanced their abilities to communicate as well as their interests in
science. These two pathways - namely, enhanced communication and interest - are the two primary themes to emerge from these focus groups.

Focus group discussions also explored issues of gender in relation to the field of science. While previous studies (Carlone & Johnson, 2007; Nosek et al., 2002) provided evidence that female science students face stigma during college and graduate school, the results of the present study provide reason for optimism that gender equality among scientists and science education may not be not far off.

This chapter begins by exploring how participating students are different from those who do not enroll in programs at the Museum, and section provides insight into the differences students perceive between themselves and non-participating students. The next section focuses on the impact the Minors and Achievers programs have had on the development of science identity. The two themes of enhanced communication skills and increased interest in science are discussed. Issues relating to gender differences are discussed in the final section, followed by a few unanticipated but interesting findings.

**Comparison Group Differences**

The focus groups yielded conflicting evidence that students who enroll in programs at the Museum are substantively different from those that do not enroll. On the one hand, several students related experiences that would define a clear outgroup of students who would not enroll in such a program. For example:

Male respondent 1: They are the type of people that don’t want to get anything. They would say “Oh, this class is so stupid, I don’t want to do this.” And they don’t ever want to do their work, they are always copying
off of someone. And that just seems to be the kind of people I get in my classes, that don’t want to do the work.

Female respondent 1: People that say that they don’t get science or it doesn’t apply to them is because they don’t care. And that’s my opinion.

These two comments demonstrate that there are students for whom science is irrelevant, and this may be linked to a broader negative attitude towards education in general. This finding naturally leads to the question: “How many of students with negative attitudes towards science participate in the Minors and Achievers programs?” Based solely on the focus group results, the answer is likely to be that only a few students who have generalized negative attitudes toward education actually participate in the Achievers program. Students in these focus groups all recognized the importance of science in their live and generally expressed an interest in science. For example, as an introductory focus group activity, students were asked to describe their favorite scientific topic. Every student was able to describe at least one topic, while most went into detail about why this topic interests them. A few students reported that they had a neutral or negative attitude towards science before enrolling in the Minors and Achievers programs:

SA Group – Female Respondent: At first I didn’t really know what I wanted to do. I just didn’t like science. With this whole program I thought “why am I here?” And over time I started exploring the Museum, and there is this part of the Museum that talks about pregnancies and I am fascinated by pregnancies. Just in general. I think that it is a cool process. And so I want to be an OBGYN someday, and I am going to make a lot of money doing that. But I am going to be a scientist because that’s cool.
Stories like these, however, were few and far between and provide evidence that students that enroll in the programs at the Museum are above average with respect to science identity, interest, and probably proficiency.

**Diversity in the Field of Science**

Participants generally expressed the belief that anyone could be a science person or even a professional scientist. The Museum may also have contributed to this view of scientists by inviting practicing scientists present to Minors and Achievers periodically throughout the program. When asked how these presenters are all the same (possibly male or boring), all respondents in one group answered with a resounding “no.” Furthermore, one respondent described one interesting presenter: “I remember this guy that came and he had a Mohawk, a pink Mohawk, he had tattoos, but he was a scientist and he knew what he was talking about. And he was fun.” This response highlights the fact that participating students view science as field of diverse individuals. This result runs contrary to the fear of many researchers (e.g., Clark, 1986; Seymour & Hewitt, 1997; Vockell & Lobonc, 1981) that the stereotype that scientists are older white males is a pervasive impediment to fostering science identity among youth.

Furthermore, rather than thinking that scientists are introverted loners who dedicate their entire life to esoteric research, the overwhelming tone of the groups was that scientists and science people can have varied interests. The first commenter below also articulates her opinion of what has been operationalized in this study as a “science person.”
SA Group – Female respondent: “…I mean I’m not a professional scientist, but I view myself as a scientist of some sort because I am interested in science. And I do stuff that other people that are not interested in science do, like I cheerlead and somebody else on the cheerleading team may hate science. So I think that it just depends on the person, not exactly what you are solely interested in.”

Girls Group – Respondent 1: “I think everybody has a little bit of everything. I’m not really a sports person but I do like playing sports just for fun. I’m not competitive, but I play sports. Then I also like reading and I like science, so I think I have a little of everything.”

Boys Group – Respondent 1: “For me it’s me more like if you are a science person you lean more towards that than anything else, more than sports or stuff like that.”

**Impact of Minors and Achievers**

A comparison group would have allowed statistical comparisons, in order to determine if there were temporal changes that were unique to Minors and Achievers. The focus groups provided an opportunity to explore these differences by asking students how they changed over the course of the program. For example, the most common impact of the Minors and Achievers programs mentioned by focus-group participants related to communication. Many students described becoming more communicative during their time in Minors and Achievers. Although there is no way to control for a potential maturation effect, it is reasonable to expect that the programs have a positive impact on communication skills, considering the emphasis that the programs put on effective communication. In addition to communication, students often mentioned increased interest in and enjoyment of science. To a lesser degree,
some students mentioned the effects the program had on their self-esteem, confidence, and work ethic.

Increased interest in and enjoyment of science are the most likely candidates for a unique impact of the program that non-enrollees would not experience. Despite the Museum’s focus on improving communication skills through these programs, it is possible that other experiences serve this function for non-enrollees. That being said, several aspects of the types of communication about which students learn at the Museum likely have unique effects on enrolled students. For example, the topics of communication stressed are focused on complex scientific topics. Students must be able to express concepts related to complex subjects such as nanotechnology and biology to the general public. In addition to the complexity of the topics, enrolled students have to be able to express these topics to visitors to the Museum in an informal setting.

**Communication**

Students in all three focus groups identified the necessity of good communication to being a successful scientist. Verbal communication was commonly described by focus group participants. In addition to verbal communication, visual methods of communication that included drawing, Photoshop, and video representations of concepts were stressed in the male-only focus group:

Interviewer: “Did anything change for you since you enrolled in Science Minors?”
Male respondent 1: “Well maybe one thing, well what I did like about science is that I could talk to other people about it and my main thing that would use to talk to other people about it would be illustrations. Yes, that’s very important for getting your point across. Like if you have a circuit board, you are not going be able to explain that in words.”

Male respondent 2: “You need to draw it.”

Male respondent 1: “Yes you need to draw it out. So my main point of communicating it was just drawing it out because I didn’t have the words for it, but this was about. It just helped with presentation and being able to explain these things.”

Male respondent 3: “I explain mine through video, a video of how it works. Because I mean a picture is worth a thousand words so a video must be worth a good million.”

Part of this discussion may have been a result of one student’s interest in art and illustrations. However, students do have access the Wanger Family Fabrication Laboratory, or Fab Lab, at the Museum that focuses on creating and fabricating objects using 3D printers and laser cutters.

Students in each group stressed in a variety of ways the benefits of the programs on their communication skills. Students described “opening up,” developing better presentation skills, and learning how to present to the interested and uninterested alike. Students most commonly mentioned the positive impact the programs have had on their general ability to communicate with others.

For example, one student articulated how the Museum helped her to improve her communication skills. The Museum also helped her to become more outgoing in general.

SA Group – Female Respondent 1: “The Museum, it helped me change in a way, like, I’ve always been pretty good at science. Since I was in
grammar school that’s just what I liked. But I think I gained additional skills that helped me with science things like experiments and talking to people about what your opinions are. Like now I’m a lot more vocal, outgoing, I can speak well to people about science or what have you. So the Museum helped me with that.”

Similar sentiments were expressed by students in other groups as well:

SA Group - Male Respondent 1: “The program kind of changed how I talk to people. Because we’ve been doing a lot about vocal communication. Before I came to the program I was pretty quiet. I didn’t talk to anyone unless I knew them really well, and if I had to I would talk really low and no one would understand me. But when I got to the Museum I was kind of forced to have to talk, to have to explain what I need to say it really fast and really well. And that has changed a lot for me and has actually given me a lot of opportunities to do other things.”

Girls group – Respondent 1: “I was really quiet before but since I got here I just opened up. And I know how to speak better, I know how to communicate better. And present an experiment.”

Boys group – Respondent 1: “It helps you with your presentation skills. So how you talk to people. This program since every time you are talking to someone new it helps me with my speaking. Because I kind of have an accent now but I really had a really thick accent.”

Taken together these two points related to communication offer insight into a possible pathway through which the Minors and Achievers programs enhance students’ science identity. Considering that students believe scientists must be good communicators, if follows that helping students to communicate scientific topics effectively helps them feel more like scientists.

However, survey results provide some qualification for this finding. Students were asked to think of five words or phrases that best describe a scientist. Of the 173
unique students surveyed, only 11 (6.36%) described scientists’ ability to communicate in some way. These descriptions included “articulate,” “good communicators,” and “good speakers.” By comparison, two-thirds of students surveyed, (66.47%) used the words “smart,” “intelligent,” or “knowledgeable” to describe scientists.

**Interest**

Creating interest in the field is another pathway in which the Museum may be enhancing students’ science identity (Lent et al., 2005). Sparking interest is also one of the six strands of science learning employed by the Museum (Fenichel & Schweingruber, 2010). While many students related that they were interested in science before they joined the Minors program, several related anecdotes demonstrate an increased level of interest in science in general.

SA Group – Female Respondent: “Before I wasn’t interested in science that much, but learning more about experiments and working with chemicals and computers, now I’m interested in computer science. So it has helped me.”

Boys Group – Respondent 1: “Now I see myself as more interested. I could see myself in 15-20 years from now doing something in medicine as opposed to a year ago when I would just see it as a career choice but it’s not for me.”

The following exchange occurred in the girls-only group. It highlights that some students’ interest in science is a general feeling and cannot be articulated very easily. Another respondent highlights that mere exposure to scientific topics on a regular basis contributes to a sense that science is everywhere. Finally, Respondent 4 hints at her public school’s inability to generate the same kind of interest that the Museum’s
programs do. This single exchange provides solid, though admittedly limited, anecdotal evidence for the effectiveness and necessity of these types of programs.

Girls Group – Respondent 4: “For me I never really didn’t like science, it was just boring for me. Sometimes I would like it. But since coming here... I talk about science a lot at home. I don’t know what it is about some things but it allowed me to open up more. So now if I’m watching the news and I hear something about... Say we had an earthquake and it knocked the earth off its axis a little, I don’t know why, but that really intrigued me. Normally, like before I was at the museum I would have been like who cares? But now when I hear something that is scientific I want to learn more about it.”

Girls Group – Respondent 1: “Maybe it’s because we see science everywhere here. Like every week we see it. And we are more interested.”

Girls Group – Respondent 3: “Like before I would see grass and it was just a plant. But now, since I’ve been in this program, I don’t know, I think of science for some reason. Anything I see I’m like, well, this happened because... or it’s that color because... something like that. I’m weird. Sorry.”

Interviewer: “Are you saying that you get excited about stuff like that more?”

Girls Group – Respondent 4: “Yeah for me... in my school we only have to take [two] years of science. But being here made me want to take more years. So as a freshman I had biology, sophomore year I had environmental science, last year I had psychology and this year I’m taking sociology and earth space science. Like now I love my sociology class and then I come here and we just got into social norms. And I started actually applying what I’m learning to stuff that I see.”

As was the case with communication, very few students used words such as “interested” or “like science” to describe scientists in their survey responses. While intelligence and knowledge were commonly reported in the survey instrument, the fact that focus group responses focused more on interest and communication may reflect an enhanced emphasis on these qualities in the Minors and Achievers programs.
**Ability and Knowledge**

One of the six strands of science learning on which Museum programming is based describes “understanding scientific content and knowledge” as a key goal (Fenichel & Schweingruber, 2010). While the present study employed an identity framework rather than knowledge, scientific knowledge may be a key contributor to a sense of science identity. Survey results demonstrated that most students believed that scientists are “smart” or “intelligent.” If this trait is central to what students consider a scientist to be, then increasing knowledge or intelligence may also contribute to a greater sense of science identity. No survey question assessed students’ grades or ability in any way. However, glimpses of the impact these programs have on intelligence were seen in the focus groups. The following student summarizes the impact the Minors program had on her ability to learn science, by describing how she liked science more.

SA Group – Female Respondent: “...I didn’t really need service-learning hours for school, so I was like there is no purpose for me being here. But then the more I did, the more I liked it, and the more I learned. Because the things we did here I ended up learning in school. I was like Oh My God, I just did this.”

This is a classic description of a mediating relationship, in which interest in science contributes to improved learning. Of course, a valid test of this mediating relationship would require quantitative data in either a longitudinal design with additional regression analyses (see Cole & Maxwell, 2007) or a randomized true experiment in which interest in science is actually manipulated systematically (see
The present focus group result, however, provides useful insight into the possibility of just such a relationship.

**Gender**

Gender effects were hypothesized to be extremely potent in relation to the development of science identity. For this reason, one focus group consisted exclusively of males and another exclusively of females. The third focus group was forced to be a mixed-gender group due to scheduling demands at the Museum. Fortunately, this third group generated lively discussion on the topic of males and females in science and provided extra insight into the issue. The discussions generally confirmed the non-significant gender effects found in testing hypotheses 1a and 2a.

The male-only focus group of Achievers had very little to say on the topic, almost as if it was a non-issue for them. One student referenced a popular cartoon show with a male scientist as the main character (Dexter’s Laboratory) and noted that his sister played the role of a scientist in a single episode.

Unlike the male-only focus group, the female-only focus group described a complex picture of their view of gender in the field of science. The following brief exchange demonstrates that initially these students latched on to the idea that scientists are mostly male. This may reflect an easily accessible stereotype or implicit attitude that is characteristic of scientists, namely that they are male. But then the conversation turns quickly into a more complex picture:

**Interviewer:** “When you think of scientists do you think of them as mostly male or female?”
Respondent 1: “I see males.”
Respondent 2: “Males…”
Respondent 3: “I think it depends on the field.”
Respondent 1: “Yeah.”
Interviewer: “Ok, so what fields do you think are more feminine dominant?”
Respondent 2: “Biology, psychology…”
Respondent 3: “I think fields like chemistry and computer science are more male dominated. I’m not saying that women don’t do them, but it’s a lot more males.”
Respondent 2: “But then there are some that are in between like being a doctor, like there are a lot of female doctors.”
Respondent 1: “I think it’s kind of the same.”

Respondent 1, who started by stating that she thought scientists were mostly male modified her position after a brief exchange to say that she thought scientists included both males and females. This complex viewpoint may be characteristic of the way in which science is perceived in the United States today. On the surface, most people will readily accept that most scientists are male. However, upon even cursory examination, most people will accept that women have the ability to be, and in fact are, successful scientists. It is also the case that there are some fields that may not currently be as welcoming.

Some of the rationale behind splitting focus groups by gender included providing a safe space for female students to express their opinions. It was not anticipated that males would be hostile toward females, but that there may be some form of pressure from males and that their presence would bias female students’
responses. While this may still have been the case, the following exchange is very similar to the one described above and was made by a female in the mixed-gender focus group in the presence of male students:

Interviewer: “Let me ask just the girls, when you think of a scientist, do you think of women? Does that come to mind at all?”

Female Respondent 1: “Not really.”
Female Respondent 2: “No.”
Female Respondent 3: “It comes to my mind.”
Interviewer: “Why is that?”
Female Respondent 3: “Because I like science and I know that women can do the same that men can do. So if a man wants to be a scientist a woman can do the same.”

At first, male students in the mixed-gender focus group did not participate in this discussion. Further probing questions helped to open up discussion, however. For example, one male student was able to articulate the historical inequality faced by women and how this has impacted their contributions to the field of science.

SA Group – Male Respondent 1: “It’s always been that women have been treated as less equal than men, so in any field that you go into women will always have a lesser standing than men, depending who the person running the business or deciding the judgments are…”

Interviewer: “Do you think that there is anything specific about science that would create that problem?”
SA Group – Male Respondent 1: “Now it might me, it’s a lot less [now] definitely, but in the sciences it’s always been viewed as a man’s job to do science, well at least that’s what I’ve been taught. Like when you look at the past it’s always been great men that discovered stuff in science but women have also discovered great things but they don’t always get mentioned.”
SA Group – Female Respondent 1: “Like, you know the helix of the DNA? You know a woman discovered that and the guys took the credit for it.”
Later in the discussion, another male respondent demonstrated an understanding that textbooks contribute to this problem. He also recognized that textbooks could be used as a potential solution.

SA Group – Male Respondent: “Usually whenever I read a textbook or something it’s always like, it’s a man’s name and then his theory. You never see [women scientists] in textbooks, but maybe if we were exposed to it more in grammar school and things like that, it would seem more like women have contributed to science. It would help us know more. We wouldn’t feel like we feel now.”

Students indicated that the programs at the Museum are contributing to a more equitable view of women in science. Later in the combined group discussion, students mentioned that the Museum staff and the scientists that come in to speak have can have an impact on students’ perceptions of gender equality in the field.

Male Respondent 1: “In this program itself, and I don’t know if it’s just me, but dominantly it seems like there is a lot more women scientists at the museum that come out and talk to us than there are men. That’s at least how I view it.”

Interviewer: “Ok, did anyone else see that?”

Female Respondent 1: “Well not necessarily official scientists. I think a lot more women volunteer at the Museum and become scientists. Become experts in a certain field, it’s a lot more women, walking around the museum in the lab coats. I mean they are volunteers, but who’s to say they are not just as smart as everybody else?”

Male Respondent 2: “There are a lot of women volunteers, but when somebody comes to talk to us, like last week someone from the ... came and they are always men.”

An unanticipated but interesting topic regarding the risks faced by scientists was developed in the mixed-gender focus group. Initially, scientists were described as
willing to take risks in the sense that scientists have to risk physical injury. When probed to describe other types of risks that scientists face, one student developed the idea of social risks:

Female Respondent: “Oh, I know. Like society risks. I don’t remember who it was. I want to say its Aristotle but, Aristotle or Galileo, they had these big ideas, and they went against the grain of what everyone else thought, and they ended up being executed because of it. Now later on down the line everyone is like, oh, he was right. But he got killed because of him being the different one, the outcast almost.”

While this is an extreme example, it allowed the discussion to flow into the area of social risks. In the modern sense, social risks are probably limited to “being wrong” and doubted by peers, as opposed to being killed by them. Additional probing questions asked students whether social risks were constant for all scientists. Several students described the social risks as being more common and possibly severe for female scientists.

Female Respondent 1: “I think women have more [social risks]. People will say more against them because they are not the majority of the field. So people will be like ‘Oh it’s a woman. What’s she talking about? She doesn’t know.’”

In general, students in these focus groups were egalitarian in their views of women’s abilities in the sciences. Several students acknowledged that women have faced, and still face, hurdles in pursuing careers in science. While these students’ opinions are only those of high school students who have not interacted with university,
graduate, and professional scientific communities, they do contribute to an atmosphere of hope for the future of women in science.

Desire to Work

During the combined focus group, several students made comments that could help Museum staff combat the significant negative relationship between students’ desire to work had on the development of science identity described in Chapter 6. For one student at least, joining Minors and continuing into Achievers was a means to working. This student joined Minors in order to pursue a paid summer internship at the Museum:

Male Respondent: “I always had to ask my mom for money and stuff, and she would always complain about it. So I heard about the program and they said they offered a summer internship but you have to go through the thing [program]. So I was like, alright I will go through it, I’ll do it for a summer and see how I like it.”

Along these same lines, several other students expanded on this idea and suggested that there be internship opportunities during the school year in addition to during the summer. This result suggests the possibility that students that continue on to the Achievers program are not only those who can afford to spend their Saturdays at the Museum. Instead, these may be students who view internships at the Museum as a viable alternative to “finding a job as soon as possible.” This possibility was not anticipated during the design of the present study. Development of school-year internships may be a potential solution to the demonstrated association between students’ desire to work and the development of science identity. School year
internships might also help to retain those students who decide to leave the program in order to make money.

**Additional Topics**

In addition to the impact of the Museum’s programs and the question of gender in science, several other relevant issues were explored during the focus groups. For example, the Achievers group was described as being like a family:

Girls only – Respondent 4: “All the achievers, we are all social. It’s hard for someone to sit in a corner and keep quiet.”

Interviewer: “Why is that?”

Girls only – Respondent 4: “Because we are like a huge family, we try to engage. If someone is sitting down and quiet, somebody is guaranteed to start a conversation and then bring them over to everybody else.”

Many other students mentioned that they had joined the program in the first place through a friend while other students mentioned that they had made friends during the program. These statements hint at a potentially unintended social component of the Achievers program that has the potential to contribute to a positive sense of science identity.
CHAPTER NINE

DISCUSSION

The current study presents evidence concerning the impact of the Museum of Science and Industry’s informal education programs on development of science identity in high school students. The following chapter highlights the implications of the current results as well as critical limitations of the present work.

Implications

The significant HLM results of hypothesis 1 are consistent with the notion that the Minors program had a positive relationship with the development of science identity in participating students. The results indicated that Minors’ science identity scores increased an average of 5.4 scale points (4.50% of the 120 point identity scale) over the course of the 10-week program. While this pretest-posttest increase was modest, so was the time in which the change took place. Since pretests were given on the first or second week of the program and the posttest was given at the end of the final session, each student received between 27 and 30 hours over 10 weeks. HLM analyses further demonstrated the significant inhibiting influence of students’ desire to find work, confirming Museum staff’s observations.

Focus group discussions provided additional insight into both the positive impact the Minors program can have on science identity as well as the negative impact wanting
to find a job can have on science identity. All three focus groups mentioned two key factors that may contribute to stronger science identification. Many students described an increased interest in science during their time at the Museum. The statements of two students from separate focus groups illustrate the effect the Minors program had on students’ interest in the field of science:

SA Group – Female Respondent: “Before I wasn’t interested in science that much, but learning more about experiments and working with chemicals and computers, now I’m interested in computer science. So it has helped me.”

Boys Group – Respondent 1: “Now I see myself as more interested. I could see myself in 15-20 years from now doing something in medicine as opposed to a year ago when I would just see it as a career choice but it’s not for me.”

Both of these students echoed sentiments of other students in endorsing the ability of the Minors program, and the Museum in general, to spark interest in the field of science. What is not apparent in the transcripts of the focus groups is the genuine enthusiasm that most of the students used to describe their experiences. Even seemingly benign topics, such as grass, were described by students with genuine awe.

In the opinion of the author, the scale and level of interaction involved in the new exhibits at the Museum are amazing. If the “Science Storms” or “You! the Experience” exhibits had been around 25 years ago, the present research may well have been about tornadoes or anatomy instead of identity.
The focus group discussions also provided evidence that the improvement of students’ communication skills was both a valuable experience for them and also a pathway to a stronger science identity. Every focus group described that scientists need to be good communicators, and every student agreed that they had learned to communicate more effectively through the Minors and Achievers programs. However, this result may reflect an important difference between the Minors and Achievers programs. The Achievers program stresses communication skills to a much larger degree than the Minors program does. Students are coached and practice effective communication on a regular basis in the Achievers program. Minors students, at the minimum, can receive 30 hours of service-learning without engaging in these kinds of activities. For this reason, a focus group of current Minors might well have yielded very different results, compared to the present focus group of Achievers. In thinking about why students continue on to the Achievers program, one factor to consider is students’ willingness to communicate. It may very well be the case that students who are shy or introverted may be deterred from progressing on to the Achievers program.

While many focus group participants described scientists as skilled communicators, survey results provided evidence that these communication skills may not be a prime driver of science identity. Students were asked to provide up to five words or phrases that they believe describes a scientist. Only a small fraction (6.36%) used the terms “articulate,” “good communicators,” and “good speakers.” To put this in perspective, the most common response (provided by 66.47% of respondents to
describe a scientist) related to intelligence. These results highlight a possible limitation of the focus group methodology for this particular study. Although students were more likely to say that they thought scientists are intelligent, it is unlikely that any student would directly state that he or she was intelligent. Some students stated they were “good at science” or receive good grades in science, but even this was not as common as students expressing interest and communication skills. Improved communication skills and greater interest may have been more socially appropriate topics to discuss in a group setting.

While improved interest and communication were both linked to being a scientist or science person, some statements illustrated the negotiable nature of science identity. Carlone and Johnson’s (2007) work, as described in Chapter 2, attributed successful formation of a scientific identity to participating women’s ability to renegotiate and redefine what it means to be a scientist. Rather than fit as stereotypical mold of what a scientist is, several women were able to form a science identity that fit them individually. In the present study, one male student described how the Museum helped him perceive science differently, through the methods, rather than knowledge, of science:

SA Group – Male respondent: “I think it opens up the way we perceive science. I know for me I realized that yeah I’m a scientist but we all make observations, we all make hypotheses. Like a small hypothesis. We don’t give it titles but we all do it. We are all scientists. It helped me realize we are all scientists. The Museum helped me think in that way.”
This student’s perception of the Museum opening up the way students perceive science resonates with Carlone and Johnson’s findings and points to a potential strength in the Minors and Achievers programs. By showing that science is a diverse field rather than a narrow one, the Museum may be allowing more diverse individuals to identity with the scientific enterprise in general.

**Desire to Work.** While the Minors program was linked to development of science identity, quantitative analyses also demonstrated that students’ desire to find paid work was associated with less temporal change in science identity. It would be advisable for Museum staff to somehow mitigate the impact of students’ desire to find work. Luckily, one focus group provided a possible answer. One student in particular described the complete opposite of this finding and reported joining the Minors program as a means of working at the Museum through an internship. One possible solution that would mitigate this negative effect of seeking paid employment on science identity would be to offer more internship opportunities or to promote the current internships more.

**Mixed Results.** The between groups analyses used in hypothesis group 2 did not provide the expected confirmation of hypothesis group 1. Minors, Achievers, and Graduates did not demonstrate significant differences in science identity. The growth of science identity appeared limited to the Minors program. This finding is particularly strange considering the high probability of “selective attrition” effects. It would follow that those students who identified more strongly as science people would continue with
the program, while those without strong identity would drop out at a higher rate. This attritional mechanism would produce artifactual differences between the groups in the study creating the false appearance of growth in science identity. Evidently, factors other than identity may play a role in students’ decisions about whether or not to continue with the programs.

**Younger Students.** Another explanation for the mixed and moderate results in the current study may be the result of the ages of the students involved. The vast majority of students participating in the Minors and Achievers programs were over the age of 14 (97.7%). It is quite possible that science identity, since it is linked to an occupation, is mostly fixed before the age of 15. Recent research has demonstrated that occupational choice, at least, is predominantly decided by the age of 14. For example, Tai et al.’s (2006) analysis of the US National Educational Longitudinal Study (NELS) concluded that 14-year-old students who expected to have a science-related career were significantly (i.e., 3.4 times) more likely to earn a physical science or engineering degree than those 14-year-olds who had different career expectations. Furthermore, a retrospective study conducted by the Royal Society (2006) asked practicing scientists when they started thinking about pursuing a scientific career. This study found that over half of the 1,141 participants (63%) reported starting to think about scientific careers before the age of 14. While it is not the expressed purpose of the Museum’s programs to encourage students to pursue careers in science, it is very
possible that students make up their minds about their interest in the field before they have the ability to enroll in the Minors program.

Based on previous research and the mixed results of the current study, the Museum may wish to focus its energies on students younger than 14 years of age. A possible obstacle to recruiting younger students could be the need for service-learning hours. Students not yet in high school (i.e., < 14 years old) are not required to earn service-learning hours, which may limit the popularity of the program and make recruiting difficult among a younger population. Fortunately, service-learning hours were not the most common reason students gave for enrolling in the Minors program in the first place.

**Gender Effects.** The lack of any discernible gender effect was a welcome surprise in the present study. There are two possible explanations for the egalitarianism observed during the focus groups. First, it may reflect the naiveté of the students. High school students may not have had the experiences that demonstrate to them that science is a stereotypically male discipline. This pessimistic possibility is less likely than the alternative view that the public’s perception of science is changing. A recent NSF report (2011) demonstrates a general increase in the proportion of scientific degrees earned by women in the 20 years prior to 2008. Indeed, female scientists and volunteers at the Museum could be demonstrating to a younger generation that women can also be successful scientists.
The current study’s finding that gender did not predict the development of science identity among Science Minors provides quantitative support for Carlone and Johnson’s (2007) ethnographic findings whereby women were able to negotiate their own scientific identity. The present findings do not fit, however, with many other recent studies (Johnson, 2007; Lee, 2002; Lindahl, 2003, 2007) that document prevalent gender effects with regards to the field of science. For example, Lee (2002) found that summer programs designed to increase students’ interest in STEM had a larger effect on female students than on male students. In addition, Johnson’s (2007) use of sociological interviews provides further evidence that often overlooked aspects of science education, such as class size and being called on in class, can discourage female science students.

It is tempting to assert that students in 2012 are less susceptible to gender effects than they were five or ten years ago. It is more likely that students who choose to enroll in the Museum’s programs report being less impacted by the stereotypically male nature of science. The opinions and ratings of students in the present study provide evidence that there is a greater perceived sense of gender equality in the field of science, at least among high school students. In light of the 2011 NSF report described above and the greater proportion of female students enrolled in the Minors and Achievers programs, there may be the hope that the stereotypically male nature of science is eroding as younger generations learn more about the field.
One qualification that bears repeating should temper the optimistic hope that gender equality in all the sciences will be reached in the near future. Many focus group respondents indicated that although males and females could both be scientists, some fields of science were dominated by men more than others. This finding supports evidence that while interest in science in general may not vary by gender, the focus of this interest does. Haste (2004), for example, found that while boys and girls demonstrated the same level of interest in science generally, female students were more interested in the “green” aspects of science and were more concerned with the environment. Conversely, male respondents were more interested in the “space and hardware” aspects of science. This gender difference is reminiscent of Carlone and Johnson’s (2007) determination that women can pursue scientific study, but are forced to do so on their own terms.

The findings of the present study and findings from prior research (Carlone & Johnson, 2007; Haste, 2004) may reflect societal weakening of the limits placed on women in the sciences. While a generation ago these boundaries were pervasive and may have kept women from the entirety of science, today these boundaries may have been pushed back or eliminated in some fields (e.g., medicine, biology, environmental science) but less so in others (e.g., physics, computer science).

Beyond the specific implications with regards to science education and science identity, the findings of the current study shed some light on the conflicting natures of identities. The science identity explored here is a very specific form of identity.
Individuals, however, are not limited to a single identity. Instead, each individual is a unique mosaic of overlapping roles and identities (Brewer, 1991). The present study touches on the idea of multiple identities in two ways.

First, science identity was set up in comparison with artistic, musical, and athletic identities and correlations between these four were weak at best. This demonstrates that students do not easily fit into a single or even a few categories. Furthermore, the number of categories included in this study was far from exhaustive. The four included were reflective of students' general interests. Other interests could have included “computer person” which may have overlapped with “science person,” or “practicing psychic” which may have seen no overlap.

Beyond interests, other types of identities could compete for a place in students’ identity development. Religious, ethnic, political, relational, and even sexual identities all contribute to an individual’s general identity. All of which could compete for salience with science identity.

Second, the impact of finding a job and the lack of impact of gender provide an interesting look into what forms of identity may compete with science identity. The negative impact of students’ desire to find a job on science identity development could point to conflict between identities relating to study versus work.

**Similarity.** The present study also provides insight into the importance of similarity to identity formation. With regards to gender this was clearest. It could be argued that since Museum staff was diverse in terms of gender, this contributed to the
absence of a gender effect on science identity development by providing multiple similar adults for students to identify with. Female students may feel isolated and unable to identify with the scientific enterprise if all staff were male. Achievers of both genders who participated in the focus groups described having met both male and female scientists while at the Museum. Some students even acknowledged the historical contributions of both men and women to the field of science. Highlighting gender diversity in any field or group may contribute to more individuals being able to identify as a member of that group.

This also provides insight into the potential value of diversity in fostering identity development. While focus group participants described scientists in stereotypical ways (smart white male with glasses) they were also able to point to scientists who did not fit that mold. Students described women scientists who made discoveries in the past, current female scientists who visited the Museum, and even a scientist with a mohawk. This helps to paint a diverse picture of scientists and allow students to find similarities with individuals who are already part of the group. Recent work by Jans, Postmes, and Van der Zee (2012) demonstrated that in addition to homogenous groups, “heterogeneous groups can also create a strong social identity” (p. 1148). Presenting science as a cohesive but diverse group may provide greater opportunities for science identity development for students that do not meet the stereotypical mold of a scientist or science person. (side note, presenting diverse opportunities may also provide a benefit by capturing those students who may see science as frivolous or conflicting with
Offering internships may serve dual purposes: (1) to broaden the definition of scientists/science person enough to draw these students in and (2) to provided valuable and necessary opportunities for students who may need to work while in high school.

**Limitations and Future Directions**

The current study is not without its limitations. First, the applied nature of the study ruled out the possibility of random assignment, necessitating a quasi-experimental design, and also limited the ability to recruit a comparison group. A comparison group of students was sought from nearby Chicago Public Schools (CPS). Unfortunately, because principals were opposed to surveying students, a comparison group could not be obtained. Multiple emails and phone calls to principals of seven nearby schools (Hyde Park Academy, Kenwood Academy, Paul Robeson H.S., King College Prep, Wendell Phillips H.S., The School of Leadership, and Dyett H.S.) resulted in a single contact with one principal who graciously declined to participate. Without a comparison group it was not possible to rule out maturational effects. It is still very possible that students of this age develop a science identity during the time period in which participating students were enrolled in the Minors and Achievers programs. The aforementioned comparison group would have helped control this potential confounding effect.

Program enrollment and structure limited both the sample size and number of time points in the present study. With less than 30 students enrolled in Minors every 10
weeks, only a multi-year longitudinal design would have been able to recruit sufficient students to generate the statistical power to observe the likely small changes in identity that take place over a 10-week program. The relatively short duration of the Minors program also limited the study to just two time points. Additional time-points would have provided even more statistical power for repeated measures designs. For these reasons, it is recommended that expansions of the present study should not be conducted by an external evaluator. Internal evaluators likely have the resources and flexibility to measure students multiple times and over longer time periods.

The failure of the Web-based survey procedure also introduced the possibility that demand characteristics (Cook & Campbell, 1979) could have confounded the results. Students’ science identity may have been primed by merely being in the Museum rather than being affected by the contents of the program. Steps were taken to reduce the likelihood of this effect during the focus groups. No Museum staff were present and the introduction specifically stated that all identifying information would be removed from transcripts of the conversations. Ideally, focus groups would have been conducted off-site to completely control for the possibility that demand characteristics influenced students’ responses.

Several planned aspects of the proposed study were unable to be conducted. First, parent surveys were originally planned based on the assumption that all parents came to the first and last sessions of the Minors program. This assumption was quickly
determined to be overly optimistic. Consequently, the parent survey was dropped, and informed consent was relaxed to passive consent.

Furthermore, a fourth group of students was anticipated for use in testing hypothesis group 2. These students represented those who completed the Minors program but did not return for the Achievers. These “interrupted” students were to be contacted through the Museum’s records and asked to complete a Web-based version of the survey. Unfortunately, staff turnover made it impossible to contact these students.

One potentially enlightening expansion of the current study would be to investigate the role science identity plays in the recruitment of students to the Museum and its programs. One potential benefit from this expansion would be to investigate what topics are most interesting to students and incorporate or advertise these in order to improve recruitment and retention. The sociological literature argues that the values of democracy, individualism, and care for the environment that are held by today’s post-materialistic (Inglehart, 1990) society are not central to the way in which science is taught in most classrooms (Schreiner, 2006). In order to draw students in, these factors would lead to crafting programming and experiences around working with others to solve modern problems such as global warming and alternative energy sources. For example, the “Smart Home” exhibit demonstrates principles of alternative energy (e.g., wind, solar) and would appeal to the values of care for the environment mentioned above. The permanent “Earth Revealed” uses a globe six feet in diameter and projects
images of the earth’s climate, and weather directly from the National Oceanic and Atmospheric Administration (NOAA) and NASA (see the Museum’s website for a review of all exhibits, www.msichicago.org). A future evaluation may focus on the appeal of these types of exhibits and compare them to other, more traditional exhibits (e.g., submarine, trains, etc.)

**Design Improvements.** Evaluation of the Museum’s youth development programs proved logistically difficult for an external evaluator. Fortunately for the author, this was a primary reason for the Museum agreeing to participate in the project. However, if the Museum is interested in pursuing this rich area of study, an internal longitudinal design with a comparison group would be the ideal study design. Museum staff have access to more age groups of students and could even survey visitors, whereas an independent researcher would have a harder time gathering such data.

If a longitudinal study design is too intensive for the resources of the Museum’s evaluation staff, then the accelerated longitudinal design (Terracciano, McCrae, & Costa, 2005) described in Chapter 4 could be useful. This design would still allow for the use of HLM and the incorporation of a comparison group, but would take a fraction of the time to conduct.

**Additional Sources.** In addition to the method proposed above, several other survey opportunities could provide additional information for the evaluation. First of all, parental surveys mailed home to parents could be incorporated for the Science
Minors and possibly the Science Achievers programs. These additional data may be useful in exploring the impact of parental attitudes on a student’s identity.

Another potential group of interest that could shed light on the development of science identity could be students in scientific degree programs. These students may be recruited from Museum records of students who had graduated from the Minors and Achievers programs or may be altogether independent from the Museum. Although students in scientific degree programs may be easy to access, obtaining a group with similar demographic characteristics to Minors and Achievers might prove difficult.

Artistic Scientists. An interesting side note that may provide a future direction for research is derived from the significant correlation between science identity and artistic identity (see Chapter 5). Much of the discussion surrounding enhancing science education focuses on STEM (science, technology, engineering, and math). The review from the National Academies (2010), for example refers to STEM education as the method with which to improve the US’s standings with regard to education and technology. There is, however, a growing belief that the arts need to be incorporated into this STEM paradigm in order to promote the creativity necessary to succeed. Rather than STEM, the acronym for this paradigm is STEAM. STEAM has recently been proposed by multiple sources as an addition to the STEM paradigm as a way to incorporate added creativity into STEM education. If the current modest correlation found in this study is just the tip of the iceberg, then including arts education into STEM
may just add a necessary component that would boost the effectiveness of these kinds of education programs.

**Conclusions**

In the context of the United States’ decline in competitiveness in the sciences (for a review see The National Academies, 2010), the Science Minors and Achievers programs are a bright spot in the field of science education. Tests revealed significant pretest-posttest increases in science identity among Minors program, and students raved about their increased interest in the sciences, their enhanced ability to communicate, their greater success in school, and for some improved self-esteem and determination. Focus group participants in particular were a font of positive insight into the Museum’s programs. Any future marketing initiatives would be well advised to use this population to put a sincere and positive face on these programs.

The present study also provided confirmation of Museum staff’s concern about students’ desire to find paid work as soon as possible. Focus group discussions provided useful suggestions for how to offset the negative impact of this factor.

Finally, while beyond the scope of the current study, it is likely that these programs may attract students who are more receptive to developing science identity. Identity levels were slightly above average among participating students and did not vary between program types; and past research suggests that many decisions about how students feel about science are set by age 14. Multiple research methods are proposed that would be useful for Museum staff in the future.
APPENDIX A:

COMPLETE SURVEY INSTRUMENT
PLEASE CIRCLE THE NUMBER THAT REFLECTS HOW YOU FEEL ABOUT THE FOLLOWING:
How well do the following describe the way you think of yourself?

<table>
<thead>
<tr>
<th></th>
<th>Not Me</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A Science Person</td>
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<td>9</td>
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<td>2. A Musical Person</td>
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<td>9</td>
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<tr>
<td>3. An artistic person</td>
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<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
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<tr>
<td>4. An athletic person</td>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

Please tell us what you think scientists are like. Then rate how much these characteristics are like you:

<table>
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<tr>
<th></th>
<th>Not Like Me</th>
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<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tr>
<td>5. ____________________</td>
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</tr>
<tr>
<td>6. ____________________</td>
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<td>7. ____________________</td>
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<td>9</td>
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<td>8. ____________________</td>
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<tr>
<td>9. ____________________</td>
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<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

How often do the following things happen to you?

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. How often does your family/caregiver(s) recognize your work/accomplishments in science?</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>11. How often do your friends recognize your work/accomplishments in science?</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>12. How often do your teachers/instructors recognize your work/accomplishments in science?</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>13. I spend my free time trying to find out more about science or scientific topics.</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
</tbody>
</table>

Please indicate how much you agree or disagree with the following statements.

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. My family thinks of me as a “science person”</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>15. My friends think of me as a “science person”</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
</tbody>
</table>
16. My teachers/instructors think of me as a “science person” .......................... 1 2 3 4 5 6 7 8 9
17. I am active in organizations or groups related to science. .......................... 1 2 3 4 5 6 7 8 9
18. I do not think a lot about how my life is affected by science. ..................... 1 2 3 4 5 6 7 8 9
19. To learn more about science, I have often talked to others outside of school. .......................................................... 1 2 3 4 5 6 7 8 9
20. I have a lot of pride in the accomplishments of science. ....................... 1 2 3 4 5 6 7 8 9
21. I feel a strong attachment to scientific fields. .......................................... 1 2 3 4 5 6 7 8 9
22. I am a very good science student. ........ 1 2 3 4 5 6 7 8 9
23. I could never be a successful scientist. .................................................. 1 2 3 4 5 6 7 8 9
24. When it comes to scientific knowledge and understanding, I can compete at the highest levels. ....... 1 2 3 4 5 6 7 8 9
25. Some of my family members do not think I could succeed as a scientist ...... 1 2 3 4 5 6 7 8 9
26. My family’s opinion of my future is very important to my future goals. ...... 1 2 3 4 5 6 7 8 9
27. I enjoy having access to the Museum outside of the Science Minors program. .................................................. 1 2 3 4 5 6 7 8 9
28. I am interested in working on a project involving scientific concepts. ..................... 1 2 3 4 5 6 7 8 9
29. Solving complicated scientific problems interests me. ............................. 1 2 3 4 5 6 7 8 9
30. I am not interested in reading websites, articles, or books about scientific issues........................................... 1 2 3 4 5 6 7 8 9
31. Communicating scientific topics to others is not interesting to me. .......... 1 2 3 4 5 6 7 8 9
32. I am interested in pursuing a career in a scientific field. ........................... 1 2 3 4 5 6 7 8 9
33. Pursuing a degree in a scientific field in college or graduate school does not interest me.............................. 1 2 3 4 5 6 7 8 9
34. The logic/methods used in scientific fields are not interesting to me. ........... 1 2 3 4 5 6 7 8 9

35. Solving scientific problems is interesting.............................. 1 2 3 4 5 6 7 8 9

36. Scientific topics do not interest me..... 1 2 3 4 5 6 7 8 9

37. I am interested in the way science can be used to help people............... 1 2 3 4 5 6 7 8 9

38. I am interested in the way science can be used to solve problems. ........... 1 2 3 4 5 6 7 8 9

39. I am not interested in helping others using science........................... 1 2 3 4 5 6 7 8 9

How important are the following to you:

<table>
<thead>
<tr>
<th>Not Important</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

40. The approval of my family/caregiver(s) .......................... 1 2 3 4 5 6 7 8 9

41. The approval of my friends .................. 1 2 3 4 5 6 7 8 9

42. The approval of my teachers/instructors ............................ 1 2 3 4 5 6 7 8 9

43. Getting a job as soon as possible. ........ 1 2 3 4 5 6 7 8 9

44. Graduating college ........................................ 1 2 3 4 5 6 7 8 9

45. Graduating high school................................. 1 2 3 4 5 6 7 8 9

46. Being popular ............................................ 1 2 3 4 5 6 7 8 9

When you think of someone who is a professional scientist, how do you compare to that person?

Very similar ....... 1 2 3 4 5 6 7 8 9 Very Different

Please rate how similar Science Minors is to the science classes you have taken in school.

Very Different.... 1 2 3 4 5 6 7 8 9 Very Similar

How many scientists do you know? ________
PLEASE CIRCLE THE NUMBER THAT CORRESPONDS TO THE MOST APPROPRIATE RESPONSE:

Is there someone in your life that you would consider to be a “science mentor?”

Yes ........................................... 1
No .................................................. 2

If yes, how do you know this person?

Parent/guardian .................................. 1
Sibling .............................................. 2
Extended family member ..................... 3
Teacher ............................................. 4
Counselor .......................................... 5
Friend ............................................... 6
Other, please describe: ............................ 7

Do you participate or enjoy any of the following:
(Circle all that apply)

After school science clubs ..................... 1
Science themed TV shows (CSI, Mythbusters, NOVA, Bones, etc.) .. 2
Advanced science classes at school (AP classes, science electives, etc.) 3
Science websites or blogs ...................... 4
Science fairs ..................................... 5
Other science activities, or events: ............. 6

Gender

Male .................................................... 1
Female .................................................. 2

What is your Birthday?

_____ / _____ / ______ month day year

Ethnicity

Hispanic/Latino ................................. 1
Not Hispanic/Latino ............................. 2

Race (select all that apply)

American Indian or Alaska Native ... 1
Asian .................................................. 2
Black or African American .............. 3
Native Hawaiian or Other
Pacific Islander ................................. 4
White .................................................. 5
APPENDIX B:

FOCUS GROUP SCRIPT
Welcome and Ground Rules (5 minutes)

Hello! Thank you all for coming and participating in this discussion. My name is Sam Cole and I am a graduate student at Loyola University Chicago.

As you may know, you were invited to join this discussion because you are a participant of the Science Achievers program. The purpose of these focus groups is to gain a better understanding of the effectiveness of Science Achievers and the Museum’s impact on how you view science in general.

How many of you have participated in a focus group before? In case you have not been in a focus group before, a focus group is a structured discussion where I will ask you a series of questions to encourage sharing of ideas and opinions. We really want you to express yourself openly and honestly. There are no right or wrong answers. We just want to know what you think.

I am going to record this session to ensure our report accurately reflects your comments. However, your responses will not be linked with your name in any way. Everything you say will be kept strictly confidential. Because we are taping, I may need to remind you occasionally to speak up or talk one at a time so that we can hear you clearly when we review the session audio tapes.

I am your guide, but I want the conversation to be among all of you. Each time I ask a question, we don’t need to go around the table to let everyone respond in turn. But every so often I may check in and make sure that we get a chance to hear from different people because it is important that we understand different perspectives. There are only (SIX) of you, so each one of your perspectives is important to hear. If you would like to add to an idea, or if you have an idea that it is different from other people’s ideas, that’s the time to jump into the conversation. Bear in mind, we’re not looking for everyone to agree here; we are looking to hear a variety of opinions and experiences.

Introductions (5 minutes)

1. Let’s begin by saying your name, how old you are, and what your favorite scientific topic is.

Introductory questions (10 minutes):

2. Now I would like to ask you about why you decided to join Science Minors and Achievers?
   a. Probe for:
      i. Service-learning hours
      ii. Parental/familial influence
      iii. Interests in science

3. What topic did you cover in Science Minors?

4. As a Science Achiever, what is your favorite area of the museum to work in?
Transition Questions (15 minutes):
5. When you think of someone who is a scientist, what comes to mind? What do you think of? (LIST)
   a. Probe for:
      i. Intelligence/smart
      ii. Creative
      iii. Curious (Critical/Questioning?)
      iv. Fun
      v. Negatives?
      vi. Physical characteristics? (Male, white, old, boring?)
6. What do you think makes someone a good scientist or just good at science?
   a. Probe for:
      i. Interests – TV, clubs, hobbies?
      ii. Can someone be a science person and say a sporty or artistic person?
      iii. Gender?

Key Questions (30 minutes):
7. How have your views of science and scientists changed since your participation in the program?
   a. Better or worse?
   b. Not at all?
8. Has your view of yourself changed (specifically your view as a science person) since before you were in Science Minors? Since starting Science Achievers?
   a. More or less interested?
   b. More or less involved?
   c. Changes in interests?
   d. Future directions?
9. What were some of the most memorable activities/events of the program (Minors/Achievers)?
   a. Did these contribute to your view of yourself as a science person? If so, how?
10. Did the program (activities, events, instructors just discussed) change your thinking? Do you think like a scientist now?
    a. Examples?

(Additional question if not already addressed)
11. Do you think that some people have an easier time with science?
    a. Who?

Ending Questions and Summary (15 Minutes):
12. Is there anything that we missed during our discussion?
13. Can you think of any ways to improve the Science Minors and/or Achievers programs?
14. Is there anything else you would like to share about the program that we have not discussed so far?

This concludes our discussion. I have enjoyed talking with all of you. Thank you again for your time. The Museum and I will be using the results of this and other focus groups (and your surveys) to help improve the Science Minors and Achievers programs.
REFERENCES


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Samuel Cole was born in Syracuse, New York, and grew up in Rockville, Maryland, graduating from Magruder School in 1998. In 2002, he completed his undergraduate studies at Dickinson College in Carlisle, Pennsylvania, where he earned Bachelors of Arts degrees in Psychology. He began his graduate studies at Loyola University Chicago in 2003 and earned a Master of Arts degree in Social Psychology in 2006. While in graduate school, he taught courses in Statistics, Laboratory in Social Psychology, and Advanced Statistical Analysis for the Social Sciences Using Computers. Currently, Sam is a Program Evaluator at Alere Wellbeing Inc. in Seattle, Washington.
DISSECTORATION APPROVAL SHEET

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The final copies have been examined by the director of the dissertation and the signature that appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval by the committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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