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ABSTRACT

In the United States, a problem previously overlooked in increasing the total number of scientifically literate citizens is the lack of diversity in advanced science classes and in science, technology, engineering, and mathematics (STEM) fields. Groups traditionally underserved in science education and thus underrepresented in the STEM fields include: low-income, racial/ethnic minorities, and females of all ethnic and racial backgrounds. Despite the number of these students who are initially interested in science very few of them thrive in the discipline. Some scholars suggest that the declining interest for students underrepresented in science is traceable to K-12th grade learning experiences and access to participating in authentic science. Consequently, the diminishing interest of minorities and women in science contributes negatively to the representation of these groups in the STEM disciplines.

The purpose of this study was to investigate a summer science research experience for minority students and the nature of students' participation in scientific discourse and practices within the context of the research experience. The research questions that guided this study are:

The nature of the Summer Experience in Earth and Mineral Science (SEEMS) research experience

A. What are the SEEMS intended outcomes?

B. To what extent does SEEMS enacted curriculum align with the intended outcomes of the program?

The nature of students engagement in the SEEMS research

A. In what ways do students make sense of and apply science concepts as they engage in the research (e.g., understand problem, how they interpret data, how they construct explanations), and the extent to which they use the science content appropriately?

B. In what ways do students engage in the cultural practices of science, such as using scientific discourse, interpreting inscriptions, and constructing explanations from evidence (engaging in science practices, knowing science and doing science)?

The following data sources were used in this study: SEEMS curriculum and documentation, interviews with program staff and participants, TRIO program documentation, Upward Bound Math Science (UBMS) promotional material, and audio/video recordings and field notes of students' daily interactions in the research setting. Findings revealed that students who participated in the research experience were able to successfully engage in some cultural practices of science, such as using inscriptions, constructing explanations, and collecting data. Analysis and observations of their engagement demonstrated a need for programs similar to SEEMS to focus on: (1) understanding how students make sense of science as they engage in the cultural practices, and (2) incorporating aspects of students' culture and social practices into the experience.

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Chapter 1

INTRODUCTION

Rationale: Introduction to the Problem

One purpose of science education is to provide opportunities for students to develop decision-making skills so that they might understand situations that are scientific in nature and autonomously make informed decisions in their everyday lives (National Research Council, 1996). As the world becomes more technologically advanced and scientifically dependent, there is a demand for a population that is scientifically literate and informed. In the United States, a problem previously overlooked in increasing the total number of scientifically literate citizens, is the lack of diversity in advanced science classes and in science, technology, engineering, and mathematics (STEM) fields (American Association for the Advancement of Science, 1994).

Groups traditionally underserved in science education and thus underrepresented in the STEM fields include: low-income, racial/ethnic minorities (Blacks Hispanics, American Indian/Native Americans), and females of all ethnic and racial backgrounds (American Association for the Advancement of Science, 1994; American Educational Research Association, 2004; National Research Council, 2007). Despite the number of these students who are initially interested in science very few of them thrive in STEM disciplines. Some scholars suggest that the declining interest for students underrepresented in science is traceable to K-12th grade learning experiences and access to participating in quality science research experiences (McBay, 1989; Stake & Mares, 2005; Zacharia & Barton, 2004). Consequently, the diminishing interest of minorities and women in science contributes negatively to the representation of these groups in the STEM fields.

The National Science Foundation (NSF) Division of Science Resources Statistics (2006) reports that of United States citizens and permanent residents, Asian and Caucasian Americans earned almost 80 percent of all science and engineering bachelor's degrees in 2004, while Blacks, Hispanics and American Indian/ Alaskan natives earned nearly 20 percent of all science and engineering bachelor's degrees. Of the 455,848 bachelor's degrees awarded in science and engineering, Asian and Caucasian Americans received 337,754 and Black Americans, Hispanic Americans, and American Indian/Alaskan natives received 75,037. Despite changes that have been implemented and years of talk about how minorities and women are underserved in science classes and STEM fields very little headway has been made (Grandy, 1998). The persistent crisis of recruiting and retaining members of underrepresented, underserved groups will continue to plague science education and the science workforce if adequate attention is not given to the matter.

The underrepresented, underserved population is predicted to become the *majority* in the United States. "According to the latest population projections, minorities (Asians/ Pacific Islanders, Blacks, Hispanics, and American Indians/ Alaskan Natives) are expected to be more than half (52 percent) of the resident college-age (18-24 years old) population of the United States by 2050, up from 34 percent in 1999" (Division of Science Resources Statistics: The National Science Foundation, 2006). This shift in the population adds to concerns regarding contributions to the scientific workforce. In 2004, there were 145,612 employment opportunities in science and engineering. By 2014, that number is predicted to rise to 164,540, a change of 13 percent in total growth (Bureau of Labor Statistics, Office of Occupational Statistics and Employment Projections, & National Industry-Occupation Employment Projections 2004-14, 2005). The existing shortages in representation of the underserved, growing *majority* in combinations with the influx in the number of jobs that require some knowledge of science or scientific practices will require a strong need and interest in recruiting and retaining a diverse population in science.

Beyond increasing the numbers of underrepresented groups in science to sustain the nation's productivity in the STEM fields, it is fitting that we pay close attention to the recruitment and retention of the underserved population**.** The goal of science education is for all students to function as scientifically literate citizens able to make informed decisions for their communal and personal well-being (American Association for the Advancement of Science, 1994; National Research Council, 1996). In order to meet this goal, it is imperative to identify and address impediments that create inequitable situations and disparities in science education and STEM fields. Arguably, students that do not perceive themselves as successful science learners and practitioners often do not succeed in the discipline.

Identifying the Major Barriers

The National Science Foundation (NSF), National Research Council (NRC), and American Association for the Advancement of Science (AAAS) are a few of the major organizations that have attempted to identify the need for change or suggested ways to implement change in science education. A common goal of these organizations is an increased focus on addressing issues relative to helping *all* students learn and access science with special attention given to the underrepresentation of minorities and women in the field.

Despite their aspirations and interests, Blacks, Hispanics, American Indian/Native Americans, and women of all ethnic and racial backgrounds often have negative self-perceptions of their abilities in science, and are less likely to pursue advanced level science courses in STEM fields. They generally tend "to have lower science achievement and inquiry skills, as well as limited exposure and access to the knowledge necessary to realize such aspirations" (O. Lee & Luykx, 2006, p. 18).

Academic preparation is one of the major indicators for success in science and STEM fields (Bonuous-Hammarth, 2000; Grandy, 1998). Many minority students and females tend not to enroll in science and mathematics courses that allow rigorous academic preparation (Bonuous-Hammarth, 2000; M. G. Jones, Howe, & Rua, 2000). Some of the barriers associated with academic preparation, race/ethnicity, and gender are often the result of institutionally based stereotypes. For example, students most frequently placed in remedial classes are minorities (Atwater, 2000; Gilbert & Yerrick, 2001; Kozol, 1991). In these classes, low-income, racial/ethnic and linguistic minority students become social misfits or outcasts. As a result, these students experience overcrowded classrooms, heterogeneous mixing of learning and physically disabled students, and rebellious and disruptive students (Gilbert & Yerrick, 2001). Students stereotyped into remedial courses often do not have the opportunity to enroll in higher-level science or mathematics courses. Furthermore, overt forms of gender discrimination are apparent in science classrooms as well (Schiebinger, 1999). Societal demands often groom males to be leaders, thinkers, and risk takers, whereby they often have more exposure to science related tasks and experiences (Ferreira, 2002; M. G. Jones, et al., 2000). Elementary school classrooms stereotype males as confident logical thinkers, traits often associated with scientists. Females are considered emotional and subjective thinkers, traits that are hardly ever associated with scientists or scientific practice. Women and sometimes ethnic/racial minorities tend not to enroll in advanced science courses. However, they do favor *softer, nurturing* sciences like Biology or Chemistry, while males enroll in the *harder* science like physics and engineering (National Center for Education Statistics, National Assessment of Educational Progress, 2005 High School Transcript Study, & National Science Foundation Division of Science Resources Statistics special tabulations, 2008). Arguably, if a student cannot visualize him/her self as a scientist or as a science learner he/she too will not enroll in advanced courses or pursue scientific fields.

Another barrier associated with academic preparation is the inadequate preparation students receive in existing school science courses. The National Science Standards recommend more hands-on, inquiry-based learning that promotes open-ended questions and discussions (National Research Council, 1996). Teaching and learning science in an inquiry-based environment helps to foster necessary problem solving and critical thinking skills for doing quality science. Unfortunately, the science teaching and learning presented in many classrooms does not accurately account for learning and doing quality science (American Association for the Advancement of Science, 1994). Instruction frequently resembles didactic teaching styles and trivial cookbook experiments, void of inquiry. These teaching practices depict science as a field that contains definite answers, where students participate in a validation process. Nevertheless, some students enjoy the validation process that cookbook laboratories provide, and decide to pursue science as a career. However, this inaccurate depiction of science gives students a false impression of the complex cognitive and social environment where "the right answer" is not always found. All students need access to curriculum that does not simply provide them with basic science skills. Exposure and access beyond general science content strengthens students' knowledge, which allows them to compete academically beyond the halls of high school and well into collegiate science courses.

Finally, in many aspects, cultural and everyday experiences play a major role in students' understanding and interest in learning science. Students from underrepresented groups tend to respond to curricula that incorporate aspects of their everyday experiences (Buxton, 2006; Warren, Ballenger, Ogonowski, Roseberry, & Hudicourt-Barne, 2001). As science teaching moves towards reflecting some practices of the scientific community in more authentic ways and fails to incorporate the cultural experiences of underrepresented groups, it becomes less likely that the field will recruit or increase the interest of underrepresented students (O. Lee & Luykx, 2006). Given that science literacy is one of the goals of science learning, the curriculum should incorporate teachable aspects relevant and significant to the culture and social concerns of underrepresented groups' learning.

Although there is no substantial evidence that affirms any intellectual or learning differences between students of underrepresented groups and others, patterns in the literature identify aspects of scientific culture as problematic in the learning processes of underrepresented students (B. Brown, 2004; Warren, et al., 2001). Some students feel that the culture and epistemology of science and scientific research presents scientific knowledge and practices as restricted to an elite group of people (Atwater, 2000). Consequently, the " … narrow view of what constitutes scientific ways of knowing can lead to a narrow range of responses to some children's ideas, which in turn can lead to limited participation by these children in science" (Warren, et al., 2001, p. 547). Their everyday experiences cannot be separated from students' science learning experiences and interests (O. Lee, 2003; Warren, et al., 2001). Culture and everyday experiences significantly shape who a student is as a science learner. Therefore, in an effort to increase the interest and representation of both minorities and women in science education and STEM fields, science education curriculum should embrace topics that are relevant and important to all students' interests and are relevant to their everyday lives.

Response of Institutions to the Problem

The National Science Education Standards recommend that science-teaching practices incorporate a more student inclusive, inquiry based approach. Science inquiry, within the context of school science, can best be described as actively engaging students in the process of constructing scientific knowledge similar to the processes that scientists employ (Schwartz, Lederman, & Crawford, 2004). However, the economic status of many urban schools does not afford them the necessary funding to provide quality instruction to students (Secker & Lissitz, 1999). Instead, didactic teaching and textbook science is commonplace. A number of research-based endeavors have been implemented in response to this disparity in science education. These endeavors target increasing the numbers of minorities entering STEM fields by engaging them in quality science, focusing on creating experiences to successfully maintain the interests of underrepresented groups in the discipline. Subsequently, institutions of higher education often implement enrichment programs as the catalyst to these research-based recommendations.

Science enrichment programs targeting traditionally underrepresented groups emphasize inquiry-based science learning, contain supplemental instruction in science and mathematics, and include some sort of mentoring aspect (L. Jones, 1997; Stake & Mares, 2001; Thomson & Brooks, 1996). Although these intervention strategies are a few that coincide with known barriers for underrepresented groups in science, their impact alone cannot be attributed to students' success in the discipline. Evaluations of enrichment programs generally use simple survey instruments or other check sheet evaluations to generalize the success of the program. This criticism does not imply that these programs do not have an impact on students' success or interest in science. However, it recognizes that science achievement, teacher involvement, and a number of other factors have been shown to contribute positively to underrepresented students' pursuit and interest in science as well.

The Research Purpose

Given that there are fewer women and minorities enrolling in advanced science courses and even fewer retained in STEM fields, research contributing to the recruitment and retention of minorities in science education and STEM fields is in high demand. This study addresses the aforementioned issues by investigating the potential benefits participation in an authentic science research experience has for underrepresented student groups.

Upward Bound Math and Science (UBMS) Summer Experience in Earth and Mineral Science (SEEMS) is the program that served as the context within which I examined the science research experience. UBMS is one of seven federally funded, Department of Education TRIO programs geared toward enhancing high school students' mathematics and science skills with the intent of increasing their interest in postsecondary degrees in those fields. UBMS curriculum incorporates researched based approaches for recruiting and retaining underrepresented groups in science. Program participants are able to take supplemental courses in mathematics and science to prepare them for the upcoming school year, interact with undergraduate and graduate student mentors through an e-mentorship, and participate in a research experience (SEEMS) at the host institution.

SEEMS is a unique addition to the TRIO UBMS program. This supplementary component is a part of a federal mandate that provides students who participate in the Upward Bound Math and Science TRIO program to have an opportunity to participate in real world science research with notable university professors at the location of the program. Students are divided into teams of 4 or 5 and given the opportunity to "…view into the professional lives of the researchers coming to understand what it means to conduct relevant research, record results in a research paper, and present research to peers and professionals" (The Pennsylvania State University: Office of the Vice Provost for Educational Equity, 2008).

The general purpose of this study was to examine a program that provides an opportunity for underrepresented students to participate in an authentic science research experience. The specific purpose of this study was to examine what happens in the UBMS/SEEMS enrichment program that reflects some of the practices consistent with research-based recommendations for recruiting and retaining minorities in science. Through an in-depth look at what occurs in the research component of the science enrichment program, I examined what happens in these research experiences relative to underrepresented students' participation in the scientific community, and their understandings of the nature of scientific practices within the context of their research experience. Moreover, I investigated the nature of the science research experience, and how underrepresented students in science view themselves as learners and participants within the science community. The research questions that guided this study were:

<u>The nature of the SEEMS research experience</u>

A. What are the SEEMS intended outcomes?

B. To what extent does SEEMS enacted curriculum align with the intended outcomes of the program?

<u>The nature of students engagement in the SEEMS research</u>

A. In what ways do students make sense of and apply science concepts as they engage in the research (e.g., understand problem, how they interpret data, how the construct explanations), and the extent to which they use the science content appropriately?

B. In what ways do students engage in the cultural practices of science, such as using scientific discourse, interpreting inscriptions, and constructing explanations from evidence (engaging in science practices, knowing science and doing science)?

The Synopsis of Subsequent Chapters

This dissertation is organized into six chapters. Chapter 1 outlines the problem, introduces some of the barriers associated with underrepresented groups in science, and identifies what institutions have done in response to those problems and barriers. This chapter also provides an overview of the purpose of the study, incorporating contextual information about the program in which the study takes place, and concludes with a synopsis of the research questions that guided the study. Chapter 2 offers insights from the literature on barriers associated with underrepresented students in science, authentic science learning, and student engagement in sociocultural practices in science. Chapter 3 presents an overview and historical background of the federally funded TRIO programs, highlighting significant details as they pertain to the UBMS program. Chapter 4 gives a detailed description of the methods used in this study, highlighting case study research, the role of the researcher, participants, recruitment procedures, data collection, and analysis. Chapter 5 presents an in-depth description of the study findings organized by research question. Finally, conclusions and implications are provided in Chapter 6.

Chapter 2

REVIEW OF LITERATURE

There is a need to increase the scientifically literate populace in the United States as a result of changes in society affected by science, and the growing need for people equipped for the science, technology, engineering, and mathematics (STEM) workforce. As a result there has been a movement to reform in science education (National Science Board, 2008) to develop a more scientifically literate citizenry. Thus, an emphasis has been placed on increasing the number of students who understand the scientific worldview, scientific methods of inquiry, and the nature of the scientific enterprise, particularly those traditionally underrepresented in STEM fields (American Association for the Advancement of Science, 1994). In this chapter I consider issues relevant to (a) barriers to entry for underrepresented groups in science, (b) the value of viewing learning as a cultural practice, (c) the importance of authentic practice, and (d) the potential for students' engagement in contextual practices of science.

Underrepresented Groups in Science

Previous studies have examined racially and gender-based barriers and have found that despite their interest, many low income, racially/ethnic minorities and women are not represented in STEM fields. Barriers commonly associated with the underrepresentation of these groups in science and mathematics often focuses on barriers associated with access that center around kindergarten through twelfth (K-12th) grade learning experiences.

Barriers associated with access to schooling

Access, for the purposes of this study, is a broad term used to identify those hindrances in the K-12 learning environments concerning academic preparation, low academic performance, school tracking, inadequate resources, teacher preparation, and teacher expectations/ motivation.

One of the more prominent barriers cited for the lack of persistence and dwindling interest of ethnic/minorities and women in STEM disciplines is inadequate academic preparation. For example, a strong indicator of students' success in science is the number of advanced level mathematics and science courses taken. However, results of studies show in many cases ethnic minorities and women tend not to enroll in these courses (Blickenstaff, 2005; Bonous-Hammarth, 2000; M. G. Jones, et al., 2000; Maple & Stage, 1991; National Center for Education Statistics, et al., 2008). Negative attitudes and perceptions coupled with poor academic performance can sometimes deter students from enrolling in higher-level mathematics and science courses. When asked about their future in science, many of these students do not hold images of themselves as scientists or as science learners, despite their interest in the discipline. These imposed differences can be the result of negative attitudes toward achievement in science or dwindling interest related to self-perception.

Another barrier deterring students from pursuing high-level mathematics and science courses is the nature of school tracking and the lack of opportunity that this form of education sometimes causes. Urban schools, which house a number of racially/ethnic minorities, are sites where a large number of students are unjustly placed in remediated classes (Atwater, 2000; Gilbert & Yerrick, 2001; Kozol, 1991). School tracking is a medium through which stereotypes are perpetuated in many institutions of learning. Most frequently, the students placed in stifling remedial classes, are minorities. In these classes low-income, racial/ethnic and linguistic minority students become social misfits or outcasts. The need to "belong" socially often outweighs the need to learn. Subsequently, students experience overcrowded classrooms, heterogeneous mixing of learning and physically disabled students, and overtly rebellious and disruptive students (Gilbert & Yerrick, 2001). This type of academic environment is often not suitable for science teaching or learning. Students placed in this line of institutionalized tracking often remain in its cycle or drop out of high school before graduation.

Salient issues linked to teacher performance and the lack of resources includes inadequate academic preparation as a result of inadequate funding. As previously noted, urban schools often house larger numbers of low income and racial/ethnic minority groups (Swanson, 2004) and repeatedly receive less funding compared to suburban and rural schools (Atwater, 2000; Haberman, 1991; Kozol, 1991). Consequently, resources needed to provide favorable learning environments, quality teachers, and funding tend to be less frequently available for urban schools (Hewson, Kahle, Scantlebury, & Davies, 2001). Favorable science education learning environments create opportunities for students to engage in hands-on activities (American Association for the Advancement of Science, 1994; National Research Council, 1998, 2001). These experiences allow students to actively participate in a learning process that stress the importance of *knowing* and *doing* science rather than finding the right answer in workbook activities, memorizing technical terms, or participating cookbook laboratory experiences. However, in many urban schools opportunities to participate in learning through this type of instruction occurs less frequently, than suburban and rural schools.

Urban school environments are often overcrowded and have a large student to teacher ratio. This overcrowding, to some extent, results in an inadequate learning atmosphere where teachers are unable to provide students with quality science instruction because of lack of time and energy (Hewson, et al., 2001). Urban schools teachers "are more likely to be underprepared and have limited access to material resources" (Clewell as cited by Hewson, et al., 2001, p.1131). Studies show that teachers who are not comfortable with their science content knowledge tend to teach science in a very restrictive manner not allowing for inquiry-based activities. They tend to rely heavily on the textbook as a source of knowledge that guides their planning and instruction

(Baker, 1998; Kahle, Meece, & Scantlebury, 2000; Carlsen, 1991, 1992 as cited in Kelly & Chen, 1999).

Negative teacher expectations can also create unfavorable academic learning environments for students' success and retention in science. Ladson-Billings (as cited in Hewson, et al., 2001) reported that low teacher expectations create an environment where students disengage from learning. As a result of low expectations, teachers' instructional strategies "did not reflect culturally relevant pedagogy, characterized by high teacher expectations, inclusion of students in knowledge production, and engagement in critiques of society's social structure" (p. 1140). It was also found that in some cases, low academic expectations and negative teacher interactions with low-income or underrepresented students are stereotypes associated with inferiority with respect to race, ethnicity, or gender (Atwater, 2000; Baker, 1998; Barlow & Villarejo, 2004; Hewson, et al., 2001; Kozol, 1991; Zacharia & Barton, 2004). Atwater (2000) notes, "the concept of race (and arguably gender-based stereotypes) is both obscured and present in American science classrooms" (p. 160). Ethnic/racial and gender based discrimination undermines students' academic abilities based upon socially constructed characteristics and/or gender bias. Hindrances caused by low expectations and lack of encouragement add another level of difficulty for these students in science and is noted as yet another reason that some underrepresented groups leave science (Dirks & Cunningham, 2006).

Learning as Cultural Practice

Another type of barrier cited for contributing to the lack of ethnic/minorities in STEM fields include sociocultural factors. Sociocultural factors are those that concern the social and cultural dissonance students struggle with as they engage with different ways of knowing. Sociocultural issues as barriers are often unobserved, even when educators seek to make science accessible and equitable for all. As a result, students' cultural beliefs and practices serve as points of conflict with many underrepresented student groups.

Sociocultural practices and beliefs cannot be separated from students' science learning experiences and interests because they significantly shape who students are as science learners (O. Lee, 2003; Warren, et al., 2001). Though it may be difficult to incorporate all aspects of each student's culture and everyday experiences into the science curriculum, ignoring aspects of culture and experience can cause adverse effects for many minority students. Bianchini, Cavozos, & Helms' (2000) study examined science teachers and university scientists' identities and views with respect to gender and ethnicity. Participants were involved in a research experience designed to increase awareness of and address issues of equity within the science classroom using a variety of instructional strategies. Cited in their review of relevant literature is Nieto's argument (as cited in Bianchini, et al., 2000) that

> Teachers can place economically disadvantaged and/or ethnic minority students at risk for learning, Nieto began, if they perceive students as not having had the kinds of experiences needed to succeed in schools. Rather than view those with little knowledge of the discourse, values, and practices of the dominant culture as doomed to failure, teachers must recognize that all students have *some* experiences that can be used as a firm foundation for learning. To address all students needs, Nieto continued, teachers must see students as having distinctive cultural identities. Some teachers may be reluctant to acknowledge the influence of cultural differences on student learning because they worry such recognition will lead to inequitable treatment. (p. 516)

This indicates how, in some cases, teachers argue that incorporating knowledge that underrepresented students bring as a result of their everyday interactions and cultural connections can make science teaching and learning inequitable. Their argument is based on the notion that students' everyday experiences are incompatible with scientific research and the understanding of scientific practices. In an effort to further understand the tension between underrepresented students and science learning Bianchini and her colleagues examined four different aspects of inclusiveness. These views were categorized as science and science teachers' perceptions of career paths; science teachers and scientists views of the nature of science; scientists and science teachers' perceptions of students' experiences; and science teachers and scientists; self-reported use of inclusive curriculum and instruction. The views of 60 scientists and teachers were examined in each of the aforementioned categories and findings from this study resulted in recommendations that encouraged

> Professional developers and science education practitioners to explore the influence of gender and ethnic identities on scientists and science teachers' professional lives; to engage in open and critical conversations about feminist scholarship of science; and to examine inclusive educational practices through the lens of students' interest and experiences. (p. 538)

Beyond the dissonance in cultural beliefs that hinder students' persistence in STEM fields is the cultural dissonance students experience as they engage in different ways of knowing created by the use of science discourse. Discourse, as a tool of expression allows students to communicate and align themselves with particular ways of speaking and being in science education contexts. This includes appropriating the use of science concepts. Students' understanding in science about a particular concept is often measured by their discourse. Discourse practices heavily shape the identity of learners within the science community. "Simply stated, identity is the kind of person an individual is interpreted to be in a given context" (B. Brown, 2004, p. 812). In other words, one's formal interactions, actions, and discursive practices shape who others see them as. Given this definition of identity, many minority students' identities as science learners depend heavily on their interactions within the science-learning environment. Success in science learning for many minority students requires culturally adapting and participating in dual cultures, maintaining dual identities (B. Brown, 2004).

It is common practice for many minority students to shy away from participating in science classrooms as a result of the vast differences in their cultural discourse and the nature of science discourse. These students rarely share their thoughts or opinions on concepts taught inside of the classroom. This is reflective of the differences in the culture of science and their everyday means of communicating (Warren, et al., 2001). To offer another explanation, this behavior may also stem from the lack of comfort the student has in the science classroom environment (Atwater, 2000). Such behaviors contribute to didactic learning environments where teachers and textbooks are the source of knowledge, and students receive knowledge without question (Atwater, 2000; Warren, et al., 2001). In order to create an environment that is inclusive for ethnic and racial minorities, understanding how they make sense of science concepts using everyday talk as a cultural resource can be valuable in informing science teaching and learning. Warren, et al. (2001) study examined science learning of ethnic and linguistic minority students. In setting the background of the study, the researchers reviewed issues of discontinuity between scientific ways of knowing and cultural means of expression and how students' everyday thoughts might *interfere* with learning. Using two cases the researchers sought to illustrate how students, who might otherwise have not participated in the science classroom discussion, engaged in meaningful discussion when able to use everyday talk to help them think and learn about a particular science concept. Discourse within science classrooms was used to emphasize the importance of understanding how students make sense of science using their everyday talk. Case 1 illustrated a discussion where students were to distinguish between growth and change. As the students interacted

> Their familiarity with each other and their deep knowledge of their first language allowed them to joke and tease on the one hand, and probe meanings and imagine change in insects and in people on the other. (Warren, et al., 2001, p. 537)

The researchers noted further

> We do not see these everyday ways of talking and theorizing as in opposition to scientific ways, or even as fully distinct from them. They seem clearly to be resources that support deep intellectual engagement. (Warren, et al., 2001, p. 537)

Case 2 investigated the logic and practice of experimentation (Warren, et al., 2001, p. 539). This portion of the study examined how well a student was able to negotiate, construct, and implement methods to manipulate variables in a scientific experiment. Findings from this case revealed how the student used his lived experience to construct and thus define "darkness" for experimental purposes. The concluding remarks of this study illustrated the importance of and potential behind including how students use their every day talk and ways of knowing to make sense of science and science concepts. These methods may increase the interest level and participation of some learners in science given that the nature of scientific discourse requires some level of questioning and reasoning as part of their involvement within the learning community.

Another aspect of the sociocultural barriers for underrepresented students is the opportunities for learners to experience culturally relevant pedagogy and curriculum. Culture is an important part of science learning; however, traditional science curriculum focuses more on covering content in textbooks under the assumption that this will assist students to receive favorable results on standardized tests. Additionally, science curricula are generally andocentric and Eurocentric, consequently lacking cultural connections and personal relevance to those underrepresented in the field (Barton, 1998; Schiebinger, 1999). What is important to note is, the major problem with curricular designs that align with the aforementioned teaching strategies is, if students are not able to make connections between the science taught in classrooms and how it applies to their lives, these remain separate. As a result, such barriers limit how students' view science as a potentially important aspect in their lives and the connections between lessons taught in science classes and applications to the natural world.

Addressing Learning as Cultural Practice

Intervention techniques commonly associated with attending to the underrepresentation of racial/ethnic minorities and women have approached the issue from the perspective of enabling access to adequate schooling. These methods involve providing supplemental instruction in mathematics and science, opportunities to network, confidence builders, mentoring, and opportunities to engage in science research. Supplemental instruction provides an academic remedy by reinforcing areas in mathematics and science. It assists students in overcoming difficulties related to their deficiencies and provides established ways to better prepare students for academic instruction in these areas. Organized peer support and social networks create an environment to tackle issues related to isolation. These groups provide support within a culture where students often feel cut off. This opportunity compels students to work together often creating a sense of community with their science groups. Early opportunities and exposure to research has been associated with increased undergraduate retention and the pursuit of graduate school degrees in science and mathematics (Barlow & Villarejo, 2004; Chatman, 2005). When successful, these opportunities allow students to participate in science research thus allowing them to see that they can *do* science. Finally, mentoring provides an aspect of encouragement similar to the relationship between teachers and students. Positive role models serve a supporting and encouraging role for these students.

These intervention techniques are important; however, they do not recognize the struggles students have because of their sociocultural differences. According to Kahn (as cited byThe National Congress on Science Education, 2003),

> a commitment to providing quality science education for all students requires an understanding of the special needs and culture of each child, regardless, or disability, gender, race, language, sexual orientation, class, ethnicity, or religion. Moreover, it requires an unyielding belief that science benefits by embracing and welcoming all students, as they bring unique viewpoints and approaches to our ever-expanding field (p. 2).

The acknowledgement and respect of the various aspects that shape identity shows that beyond the barriers of access, each student's identity is shaped by who they are, their socioeconomic status, and a number of other factors that play a role in what each student brings to the science classroom.

An alternative approach is required to reduce the disproportionate numbers of students of color and women who fail to have sustained interest in science because of barriers associated with the culture and the nature of science. This approach should reflect the needs of underrepresented learners on a cultural level. Students from underrepresented groups tend to respond to curricula that incorporate aspects of their everyday experiences and /or when curriculum has some personal relevance (Buxton, 2006; Warren, et al., 2001). What is important to note in this subsection is that ignoring issues relative to student culture and everyday ways of knowing creates a barrier for underrepresented groups and learning. Thus, science learning experiences should allow students to incorporate their cultural practices as a way to understand science concepts, expose students to topics that are relevant to their culture and lived experiences, and highlight contributions of all persons in science.

Teaching and learning in ways that incorporate aspects of students' social and cultural ways of knowing provides an opportunity for learners to connect science with their everyday lives and means of expression. This is not to discredit scientific ways of thinking or expression; however, this manner of teaching and learning science provides an opportunity for learners to grasp science content by acknowledging the cultural practices of the learner. While intervention strategies traditionally focus on providing access and opportunities for groups traditionally underrepresented in science, recognizing the significance of learning as cultural practice and how to incorporate social and cultural ways of knowing is important in creating equitable science experiences for all students specifically those underrepresented in science. Understanding and giving specific focus on how students use everyday talk to interact and culturally express themselves within science learning environments can be used as a means to incorporate different ways of knowing and learning. This attempt at constructing an environment that acknowledges the different ways minority students culturally express themselves using everyday language incorporates and acknowledges learning as a social process that integrates the cultural practices of the learner. In recognizing the importance of learning as cultural practice, I draw attention to how learning is situated; the importance of discourse and identity in teaching and learning; how students legitimize themselves within community of practice using discourse; and the importance of acknowledging sociocultural perspective in learning.

Brown, Collins and Duguid's (1989) situated cognition model suggests that learning and cognition are situated. This means "the activity in which knowledge is developed and deployed, it is now argued, is not separable from or ancillary to learning and cognition. Nor is it neutral. Rather, it is an integral part of what is learned" (J. S. Brown, Collins, & Duguid, 1989). The situated cognition model reinforces that acquiring knowledge happens best when the learner participates in the practices of a culture. Their argument is that successfully acquired knowledge comes through immersion into the community of practice. Such immersion provides exposure to authentic practices of the culture, allowing the individual to experience learning through structured activities, *social interactions*, coaching and modeling. While all of the aforementioned aspects highlight different aspects of learning science, this study focused on participants' engagement in an *authentic* science research experience as one part of a community of science practice. Specific emphasis was given to aspects of the participants' discursive practices within a science research group as a measure of how they made sense of science concepts and engaged in the cultural practices of science. Lemke (1993) argued:

> Whenever we do science, we take ways of talking, reasoning, observing, analyzing, and writing that we have learned from our community and use them to construct findings and arguments that become part of science only when they become shard in that community. Teaching science is teaching students how to do science. Teaching, learning, and doing science are all social processes: taught, learned, and done as member of social communities, small (like classrooms) and large. We make those communities by communication, and we communicate complex meaning primarily through language. Ultimately, doing science is always guided and informed by talking science, to ourselves and with others. (p. xi)

Arguably, learning occurs in the presence of interactions fostered within the context of the science learning environment. Thus, student social and discursive practices significantly shape how learning occurs. Examining how students engage in and make sense of science concepts can provide a better understanding of the different ways of expression used by students traditionally underrepresented in science.

The nature of scientific discourse causes students to feel that scientific practices require separation between their everyday dialogues and school science. The separation of the two environments forces students to maintain dual linguistic identities if they want to “fit in” (B. Brown, 2004). While this study does not focus on identity as a major construct, it is important to note who the students are as learners, and how they interact within the learning environment. Brown (2004) uses the term discursive identity to explain how some students culturally adapt to the culture of science. This notion of “[d]iscursive identity reflects an understanding that speakers select genres of discourse with the knowledge (tacit or implicit) that others will interpret their discourse as an artifact of their cultural membership” (B. Brown, 2004, p. 813). Using four domains, Brown provides descriptions and characteristics that illustrate students’ affinity inside the culture of science. These domains include Opposition Status, Maintenances Status, Incorporation Status, and Proficiency Status. The descriptions associated with each domain ranges from full denial of content knowledge to students engaged in discourse about science in an all-embracing way. Knowing how ethnic/racial minority students’ discursive identity shapes their responses in the science-learning environment can provide insight into how they have achieved access inside the science classroom culture.

Learning as cultural practices is a sociocultural approach to teaching and learning science that shifts learning from an isolated process to one that acknowledges the roles that social interaction, identity, and community play in learning. Lemke (2001) states:

> sociocultural perspectives include the social-interactional, the organizational, and the sociological; the social-developmental, the biographical, and the historical; the linguistic, the semiotic, and the cultural. For many researchers they also include the political, the legal, and the economic, either separately or as implicit in one of the others (p. 297)

While science learning previously focused on knowing content knowledge and the *scientific process*, a subsequent approach now focuses on learning by *doing* science. Learning as cultural practices incorporates aspects of the cognitive and epistemic practices of science while recognizing that knowledge is socially constructed within varying communities of practice and does not occur absent of culture. Unlike the traditional science teaching methods, this approach focuses on engaging students in the cultural practices of science; such that they are able to learn science in meaningful ways that connect their science learning to the natural world. Furthermore, this approach acknowledges students' identity within the framework of knowing, understanding that aspects of everyday life are influential in their learning process. Overall, this perspective of science learning makes the lines between what is considered *scientific* and the natural world more cohesive. What this means is that a sociocultural perspective makes science *human* and *applicable* within the context of our lives. In the subsequent section, I introduce inquiry through authentic practice as an approach to addressing the needs of these students outside of the traditional approach which has primarily had been focused on alleviating barrier by managing issues concerning access.

Authentic Practice

Teaching science through inquiry is an approach to teaching science that provides opportunities for students to participate in hands-on activities that allow them to engage in

> the diverse ways in which scientists study the natural world and propose explanations based upon the evidence derived from their work. It also refers to activities of students in which they develop knowledge and understanding of how scientists study the natural world. (National Research Council, 1998, pg. 23)

Inquiry based practices have a primary focus on creating authentic science learning experiences. This application of learning science allows students to engage actively in activities that foster critical thinking, problem solving, evidence collecting, and validating evidence-based claims (National Research Council, 2001). These practices encourage students' natural inquisitiveness and cultivate their ability to probe and question. Furthermore, inquiry based teaching strategies help create opportunities for students to engage in doing quality science and acquire skills that would help broaden their outlook and approach to problem solving, while introducing them to the nature of science. Authentic science learning should contain elements of the cognitive, social, and discourse practices that make up scientific research. The purpose of experiencing science in this "authentic" manner is to provide science learners with an opportunity to acquire contextual knowledge within a scientific community by engaging in the practices and employing science tools and techniques (Edelson, 1998) with the intent of making the connections between concepts and their application (Buxton, 2006; Edelson, 1998; Lee & Songer, 2003). Moreover, some aspects of authentic science focus on incorporating aspects of everyday life into the science curriculum with hopes to appeal to student interest (Edelson, 1998). However, despite research-based recommendations, access to quality science learning through inquiry rarely happens in schools (Anderson, Holland, & Palincsar, 1997). The opportunity to engage in quality science learning through inquiry is reduced tremendously in urban science classrooms compared to suburban and rural science classrooms due to inadequate funding and inadequate teacher preparation.

Authentic science in schools should combine views of science learning that engage learners in science experiences which closely reflect the cognitive practices, social practices, and discourse of the scientific community. However, to say that authentic school science should only encompass the perspectives of the scientific community without regard to the cultural and/or social affect of the science learners is problematic. School based authentic science inquiry should also incorporate a balance between learning experiences that are socially and culturally relevant to learners' everyday lives while maintaining some level of authenticity to scientific research, recognizing that not all aspects of everyday life and scientific research can apply (Buxton, 2006; Edelson, 1998). It should also take into account the discourse practices of learners, recognizing that the dialogue of the science community can create conflict with the identity of its learners (B. Brown, 2004; B. Brown, Reveles, & Kelly, 2005).

Authentic science opportunities can be broadly partitioned into two contrasting views: hereafter referred to as the Canonical Science Perspective, CSP, and Applicative or Sociocultural Perspective, ASP. CSP positions Authentic Science Learning as a teaching methodology that engages learners in science experiences that precisely reflect the cognitive and epistemic practices of the scientific community. ASP recognizes Authentic Science Learning as a teaching methodology that acknowledges the importance of the cultural practices of science; however, ASP also provides opportunities for students to learn and experience science concepts connected to “everyday-life” problems or experiences. While both aspects offer opportunities to participate in science in authentic ways, aspects of ASP humanize science by accounting for student interest and recognizing that students’ values and perspectives are important, thus, acknowledging that their practices and beliefs help them make sense of how things have come to be and function.

While the focus of this study examines authentic science from the ASP, to distinguish between the two different perspectives I highlight CSP as represented by Chinn and Malhotra (2002). Their research addressed the need for K-12 science to incorporate inquiry-based learning activities that emphasize doing and learning science through the inclusion of genuine scientific practices. “Authentic scientific inquiry refers to the research that scientists actually carry out. Authentic scientific inquiry is a complex activity, employing expensive equipment, elaborate procedures and theories, highly specialized expertise, and advance techniques for data analysis and modeling" (Chinn & Malhotra, 2002, p. 177). Chinn and Malhotra (2002) argued that many *authentic* experiences misrepresent scientific reasoning when they employ simple inquiry tasks to illustrate the processes of authentic inquiry used in scientific research. The consequence of these misrepresentations is students who are unable to employ scientific reasoning skills beyond the classroom setting.

Their theoretical framework examined the differences in the epistemology and the cognitive processes of scientific inquiry and simple inquiry using textbook lab experiments as a reference for analysis. They identify three components of inquiry: experimentation, observation, and illustration; and compare the cognitive processes associated with each component in the context of both simple and authentic inquiry. Specifically they examined the differences in how researchers and students formulate research questions, develop studies, make observations, explain results, and build theories. Findings from their research concluded that inquiry activities depicted in most classroom textbooks have very little resemblance to those related tasks in a scientific practice. While I agree that many textbook examples of inquiry are misleading and trivialize the idea of participating in scientific inquiry, CSP does not place any emphasis on how to incorporate aspects of students' everyday lives into the science. ASP has a primary focus on incorporating these aspects of inquiry-based learning.

Particularly with underrepresented student groups, ASP has demonstrated the potential to increase the interest and participation of science learners. For example, Rahm's study (2002) used an informal learning context to examine what opportunities were present for underrepresented students to engage and learn from participation in an informal science experience that had some relevance to their everyday lives. The study follows a group of six students of color in an eight-week community-centered gardening program facilitated by four team leaders to examine how students make sense of science concepts when science education was not explicitly the program goal. Thus, participation in the program allowed learners to work within an environment of particular interest to their community while teaching students essential life skills and uses of gardening. Analyses of the data sources within the cultural context of the program found:

> The gardening program supported diverse learning opportunities, some of which were embedded in the structure of the activities and further supported by the environment, whereas others emerged from the youths' action and talk in the garden and its surrounding community. Most important the science that got done emerged from the youths' interactions with the garden and with each other and was constituted by the garden. (Rahm, 2002, p. 178)

The questions generated by students created opportunities for the team leaders to incorporate different science concepts. Furthermore, their hands-on involvement promoted a social network of learners engaged in cultural practices of gardening while sustaining their interest. Student took away valuable insight and understanding of how science and their communities interconnected. They also showed greater appreciation for nature and its connection to their lives through this experience.

Buxton's (2006) 2-½ year study of an at-risk Louisiana school highlighted student participation in authentic science from an ASP. Using video, interviews, and artifacts from students, Buxton highlighted issues within the curriculum, instruction, and assessment of classroom practice from a culturally relevant view of practice. His findings indicate that students were most interested when they were experiencing science in ways relevant to their everyday lives. Consequently, the students became equal participants in the learning process by taking advantage of teachable moments within the classroom. Recommendations from the study suggest:

> all learning goals must be collaboratively constructed by all members of the learning community, taking into account the values, needs, and desires of all stakeholders; and that equal emphasis must be placed upon both the relevant science learning experiences themselves and the social issues/actions that are embedded in those science experiences. (Buxton, 2006, p. 719)

Despite the demands of high stakes testing, the *contextual* curriculum model was successful in creating positive science learning experiences for the participants in this study by bringing together relevant content standards and topics with critical social relevance (Buxton, 2006).

Basu & Barton's (2007) study looked at the relationship between students' sustained interest in science through their lived experiences (funds of knowledge) over time. Using an ethnographic approach to examine an afterschool program, the researchers set out to examine what influence students' lived experiences had on their sustained interest in science. Three themes emerged out of their findings:

> (1) a strong connection between sustained interest in science and authentic opportunities for students to develop skills that advanced them toward their visions of their own futures, which includes both personal and professional desires (p. 479);
>
> (2) there was a strong connection between a sustained interest in science and science learning environments in which students were able to cultivate relationships with people in ways that reflected their values of relationship and community (p. 483); and
>
> (3) agency and usefulness are centrally connected to how students activate their funds of knowledge in support of a sustained interest in science (p. 485).

The implications of their findings emphasized that students' vision, a strong social network, and the usefulness or the connections between school science and their every day lives were grounds for sustained interest and persistence in science.

A recurring theme that seems to resonate in the aforementioned ASP studies is that there is a need for students to engage in science in ways that promotes a sustained interest in the discipline, and the best way to do so is to create learning experiences that have relevance to students' everyday lives. Implementing curricula or experiences that have cultural relevance has the potential to reduce sentiments of "boredom, anxiety, confusion and frustration" (Basu & Barton, 2007p. 446). While culturally relevant experiences are important, another approach to increasing student interest is the use of technology within a classroom environment to incorporate inquiry into the science classroom.

Edelson (1998) used technology as an instrument to illustrate the integration and use of authentic science into classroom practices. His study incorporated the use of the Learning Through Collaborative Visualization (CoVis) project as a curricular resource that provided teachers with an opportunity to present their students with small-scaled *authentic* science research. The findings from this study support the value of authentic inquiry within the teaching and learning of science. However, the focus was not solely incorporating authentic science research into classroom practices. Edelson (1998) addresses authenticity within science classes and uses "curriculum structures, teacher support and adaptation of scientific tools and techniques to describe some underlying themes in this research and to highlight some distinguishing characteristics of a number of these projects" (p. 325). His study identified the need for focusing curricula on issues that would allow students to engage in authentic science issues relevant to their lives, something of familiarly. By engaging students in locally relevant issues, they are able to make the connections between what it is that scientists do and its application to their everyday lives. Furthermore, he used CoVis to illustrate the need for teachers and students to have communities of practice. While students use the electronic community to collaborate and share, analyze, and evaluate data, CoVis also provides teachers with a community that facilitates professional development and networking where they could share practices and offer support and guidance. The student-to-student interactions and other communication techniques CoVis provided offered students an environment that supported scientific reasoning and collaboration. The teacher-to-teacher interaction allowed important opportunities for support among teachers around their efforts to facilitate inquiry within their classrooms.

Similar to Rham (2002) and Buxton (2006), Edelson (1998) highlighted the importance of both the role of the teacher, as well as, the need to make learning more culturally relevant or applicable. Lee and Songer's (2003) study also used technology to implement inquiry into the science classroom. Their study identified the characteristics of genuine scientific situations that contribute most to the development of knowledge in inquiry (Lee & Songer, 2003, p. 928). Using situated learning to construct their framework, their argument was, "what is important in situated learning is to understand the interrelationships among learners, activities, and world that is defined, in a community of practice" (Lee & Songer, 2003, p. 924). Utilizing an inquiry-based curriculum, Kids as Global Scientists (KGS), Lee and Songer (2003) further investigated the importance of science inquiry in learning; the role of authentic activities in inquiry learning; and the transformation of scientific inquiry for students. Their findings demonstrate that authentic school inquiry needs to provide students with opportunities to employ the cognitive and social practices of the science within a science community. Furthermore, the integration of scaffolding techniques would be required in those cases where research issues are too complex for the classroom.

While some aspects of this experience would classify this approach as canonical (Buxton, 2006), their overall framework identifies authenticity within their research by concentrating on real world science issues that connect with situations relevant to students' problems within their everyday experiences. The findings of this study pointed out that students often do not have extensive knowledge of content that resemble scientists, and "authentic science tasks should be developed through the simultaneous transformation of content knowledge, scientific thinking and resources" (Lee & Songer, 2003, p. 944). However, this transformation of content knowledge is not something easily done for students. Consideration for students suggests that they receive support and guidance throughout their learning.

All of the studies mentioned thus far have focused on incorporating aspects of science practices to students' everyday lives or making a connection between personal experience in science and how these are characteristics of science that motivate learners. I agree that personal relevance and/or seeing connections between what is taught/experienced and the natural world is important. However, these studies do not examine the complexities many minority students face with how their discourse practices shapes their *identity* within the cultural practices of science combined with the exposure to research environments. This pattern in the literature associated with science learning provides insight into how some marginalized students use *discursive identity* to express their identities as science learners.

Student Engagement in Contextual Practices of Science

The previous sections of this chapter outlined barriers associated with underrepresented groups in science as it pertained to limitations associated with access in K-12 learning experiences, and addressed the relevance of learning as cultural practice. Moreover, emphasis was placed on authentic practices through authentic science learning experiences that provided an illustration of how teaching and learning from an ASP recognizes the extent to which incorporating sociocultural practices effect science learning for underrepresented groups. Drawing on this literature, I conclude this chapter by restating my research problem in light of the critical nature of the sociocultural perspective on science learning for underrepresented students.

There is a long history of ethnic/racial minorities and women underrepresented in STEM disciplines. Factors that continue to contribute to the low numbers of these groups in science include limited access and barriers associated with the sociocultural issues related to the science curriculum. As previously stated, urban schools generally house large numbers of ethnic/racial minority students, and these schools often have considerably less funding compared to suburban and rural schools. As a result, students enrolled in these schools face a number of challenges related to access. Among these barriers are: inadequate academic preparation, lack of opportunity because of remediation, low teacher expectations, lack of resources, and uninspiring instructional methods. Intervention strategies used to address these issues include accessibility to authentic practices in science through research experiences or hands-on learning experiences within the science classroom environment. Other strategies include providing students with a peer and mentoring support network and access to advanced level mathematics and science courses.

While the aforementioned techniques address the different barriers associated with access; they do not address those issues concerning the social nature of science and the social construction of knowledge within these environments. Brown's (2004) piece on identity was used to illustrate how student discourse is an important way to understand the different ways underrepresented students identify with the culture of science. However, the more important piece surrounding discourse is the interaction students have within the varying communities of practice; How they engage in the research experience and make sense of the content within the community of practice.

The primary focus of this study was to examine students' interactions while participating in a science research experience. Using the Upward Bound Math-Science (UBMS) Summer Experience in Earth and Mineral Science (SEEMS) program, I examined the nature of the UBMS: SEEMS program and the nature of the students experience within an *authentic science* research setting. Specific objectives for this study were (1) to examine the intended outcomes of the SEEMS program compared to the enacted curriculum, (2) to investigate the extent to which participants were able to make sense of and use science concepts as they engage in the research experience, and (3) to examine the ways participants' engage in *doing* science. Through examining these aspects of the UBMS program, I hoped to contribute to literature on underrepresented groups in STEM fields by providing insight into how students interact in science research settings as part of a university attempt to provide opportunities that would stimulate interest and prepare students for a career in a STEM discipline. In the ensuing chapters, I provide more information about the context of the program and methodological approach used to examine the objectives of this study.

Chapter 3

CONTEXT OF UPWARD BOUND MATH-SCIENCE (UBMS): SUMMER EXPERIENCE IN EARTH AND MINERAL SCIENCE (SEEMS) PROGRAM

Overview

This chapter provides an overview of the background and chronological development of the federally funded TRIO programs, with emphasis given to when programs were created and their purpose, in order to establish the historical context of Upward Bound Math-Science, and introduce the Upward Bound Math-Science program. Presenting Upward Bound Math-Science in smaller subsections will provide insight into (i) how the program is funded, including the application process for institutions and agencies and mandated curriculum, and (ii) participant eligibility. The final component of this chapter will (iii) introduce the Upward Bound Math-Science program at The Pennsylvania State University, University Park, and provide an overview of the Summer Experience in Earth and Mineral Science (SEEMS).

Historical perspective

The name TRIO represents three pilot programs that were developed under the Economic Opportunity Act of 1964 and the Higher Education Act of 1965 in response to an address given by Lyndon B. Johnson, 36th President of the United States. President Johnson, in his address titled The Great Society, communicated the need to confront prevailing issues of inadequacy and the lack of opportunity in the areas of medicine, education and economics for many Americans.

Among the programs developed that attended to the under preparedness of the educational system were Upward Bound, Talent Search, and Special Services for Disadvantaged Students.

The Economic Opportunity Act of 1964 authorized the development of Upward Bound. The purpose of this program was to encourage and motivate students from low-income, first generation college families to complete their secondary education while providing them with guidance and motivation to pursue postsecondary education opportunities. All Upward Bound programs are required to include reinforced instruction in English, Foreign Language, Science and Math. Also included in the intended curriculum and helping to achieve the mission of the program, students receive academic and financial counseling, assistance with their college application process, and preparation for college entrance exams. Upward Bound started as a pilot program with 18 sites and grew exponentially, establishing 220 sites by 1966. Even today, Upward Bound programs continue to exist having served over an estimated 800,00 participants by 2006 (Research Triangle Institute, Curtin, & Cahalan, 2004; U.S. Census Bureau, 2001).

Talent Search was the second program established in the line of TRIO programs. Established under the Higher Education Act of 1965, Talent Search, which assists disadvantaged students, has a different target audience. The Talent Search program services high school dropouts and provides career counseling in addition to academic and financial counseling. Participant requirements for this program are slightly different, given that consideration is given to the interned service population. Whereas participants who enroll in Upward Bound must have completed the eight grade and exhibit a need for academic support, Talent Search participants are restricted to individuals between the age of 11 and 27 who show proof of completion of the fifth grade. The program offers some of the same resources provided by Upward Bound; however, additional services are included, such as career exploration and assistance on reentering the academic setting where they left off.

Special Services for Disadvantaged Students (SSDS) marks the third program established and thus the name TRIO was coined. Created in 1968 and later renamed Student Support Services (SSS), this program is similar to Upward Bound and Talent Search, and seeks to serve the underprivileged population. However, unlike any of the programs before it, SSS works to retain and successfully graduate students from institutions of higher education while also helping students in their transition between levels of education if applicable. Students enrolled in this program may receive financial assistances in the form of Pell Grants pending qualification. In addition, participants can enroll in developmental/remediated courses intended to help enhance their skill set and apply for assistance to help with their graduate school application process. Unlike Upward Bound, yet similar to Talent Search, SSS participants are those individuals who identify as low-income, first generation college students or have an identified academic disability. Student Support Services can be found at a number of institutions nationwide and continues to work toward fostering a supportive climate for students categorized as being "at risk," "marginalized" or "underprivileged" in America.

Introduction to Upward Bound Math-Science

The Development of the initial TRIO programs paved the way for the establishment of many other programs. Among those programs is Upward Bound Math-Science (UBMS). The United States Department of Education (2004) reports that

> UBMS began in the early 1990's as an initiative to help address national concerns about attracting and retaining more students within science and mathematics in the light of predicted shortfalls in the number of individuals entering science and mathematics fields. It was recognized that the United States could meet future potential shortfalls of scientists and engineers only by reaching out and bringing members of underrepresented minorities into science and engineering. (p.1)

Through their participation in UBMS, students are offered academic programs, tutoring, mentoring, counseling, and preparation for applying to and entering into college. Furthermore, “[t]he goal of the program is to help students recognize and develop their potential to excel in mathematics and science and to encourage them to pursue postsecondary degrees in math and science” (Research Triangle Institute, et al., 2004, p. 1). UMBS participants receive rigorous enhancement in math and science in addition to the traditional supplemental instruction in English composition, foreign language, and English Literature. Essential to the intended mission of Upward Bound Math-Science is that the program also provides opportunities for participants to engage in scientific research with faculty members or graduate students at host institutions in an attempt to expose and possibly attract students into mathematics and science professions.

UBMS Funding

The government reserves funding for TRIO programs each fiscal year based upon the President’s approved budget (U.S. Department of Education: Office of Post Secondary Education, 2007a). Thus, as part of the Federal TRIO budget as a whole, UBMS is allocated funds underneath this charge. Public and private agencies and institutions of higher education submit applications requesting funding programs at their respective sites. For consideration, institutions and organizations seeking funding must show commitment to designing, implementing, and conducting programs that provide support for underprivileged students, encouraging them to pursue post secondary education with a primary emphasis on attracting and retaining students in mathematics and science disciplines. Submitted applications undergo an extensive review process by leaders outside and within the intended population to be serviced, including federal and non-federal government employees. The Department of Education’s management determines budget allocations based on a number of factors highly dependent upon the design, need, prior history and/or funding request. Funds allocated have ranged between $170,000- $270,000 or more per program with first year projects receiving a determined amount based upon the allocated amount set for new projects. Existing project budgets are based upon the years of previous funding and program evaluation. Awards are generally allocated for approximately 2-5 years depending on the review process or unless otherwise stated.

Projects selected for funding must meet certain criteria. According to a report issued by the United States Department of Education Office of Postsecondary Education Federal TRIO Programs, all UBMS projects must provide participants with opportunities to engage in mentoring, networking, and other opportunities throughout the school year. These opportunities are given in conjunction with a minimum six-week enrichment program during the summer whereby students are exposed to life on a college campus and are exposed to an authentic, hands-on experience in either mathematics or science at research sites. Other components of UBMS include academic support, counseling, and computer training. Though the aforementioned components are listed, each institution, organization, or agency has some autonomy regarding what their individual program looks like. However, in general all UBMS programs have a primary focus on providing students with an opportunity to take supplemental classes that will strengthen their overall abilities in core curricular classes with emphasis on specific mathematics and science courses they will take in the fall following the program.

Eligible Participants

Participants eligible for Upward Bound Math-Science originally were pulled from Upward Bound; however, this is no longer the case. Independent of Upward Bound, Upward Bound Math-Science students are selected based upon recommendations from school officials, often counselors and teachers. Furthermore, each participant must be a United States citizen or show intent of becoming a United States citizen, have completed the eighth grade, show current enrollment in high school with intent to pursue postsecondary education in math or science, and meet certain financial requirements.

> Two thirds of project participants must be low-income (defined as an individual whose family's taxable income did not exceed 150 percent of the poverty level; e.g., the income level for a family of four was approximately $26,2475 in 2001) *and* potentially first-generation college students. 'Potentially first-generation college student' means that neither of the student's parents has completed a bachelor's degree. The remaining one third of participants must be *either* low-income or potentially first-generation college students. (Research Triangle et al., 2004)

The demographic makeup of many of the UBMS program sites represents those students from ethnic minority groups. A 2000-01 report shows that African American and Latino participants made up 40.7% and 19.8% of those students who participated in UBMS; whereas, Whites and Asians represented 24.8% and 7.4% respectively (The Pennsylvania State University Department of University Publications; U.S. Department of Education, et al., 2004).

<u>Upward Bound Math-Science at The Pennsylvania State University</u>

Similar to many UBMS programs, the program at The Pennsylvania State University-University Park campus (Penn State) provides the required curricular components mandated by the Federal TRIO initiative. As previously mentioned, students enrolled in UBMS take supplemental classes to strengthen their abilities in core curricular courses with specific attention given to courses in mathematics and science disciplines. Some of the courses offered at the Penn State site include Algebra II, Geometry, Trigonometry/ Pre-calculus, Honors Calculus, Biology, Chemistry, Physics, Research Writing, and SAT Preparation. According to UBMS Penn State's website (Web Coordinator, 2008) and brochure (The Pennsylvania State University Department of University Publications, unknown) additional activities include training in the use of Microsoft Office™, conducting internet research, writing literature reviews, and implementing scientific methods. Also noted is that the program offers its participants supporting activities in the form of college visitations and seminars in leadership, diversity, teambuilding, and mentoring.

Students who participate in the program are generally between the ages of 13 and 18 and are able to continue in the program throughout high school, returning each summer to engage in the enrichment and research components. Located in central Pennsylvania, Penn State often recruits from surrounding areas including Reading, Philadelphia, and Harrisburg. Unique to this program is its partnership with The Alliance for Earth Sciences, Engineering, and Development in Africa (AESEDA). AESEDA is part of a global project hosted by Penn State's College of Earth and Mineral Science to "develop and foster interdisciplinary research, education, and outreach initiatives aimed at harnessing georesources for sustainable livelihoods in Africa with a focus on underrepresented populations" (The Pennsylvania State University: College of Earth and Mineral Sciences, 2005-2006, p. 2). AESEDA's participation enables the recruitment of participants from Selma Early College High School (SECHS) funded by the Bill and Melinda Gates Foundation. Students from SECHS are unique to the Penn State project. These students travel from Alabama each summer to participate in the UBMS experience. Furthermore, students who attend SECHS are exposed to college-level curriculum whereby upon completing high school are awarded an Associates Degree form Wallace Community College of Selma.

A federal mandate also requires each project site to offer participants an opportunity to engage in hands-on experiences and to work with scientists involved in research. To meet this requirement UBMS at Penn State provides students an opportunity that combines both of these requirements. The additional component, also thought of as an authentic research experience, allows students an opportunity to work with faculty/ graduate students in the College of Earth and Mineral Science (EMS). This program is known as Summer Experience in Earth and Mineral Science (SEEMS). Students are grouped together with a faculty member in EMS who serves as their faculty mentor and teacher over the six-week period. The selection process for each group is pre-determined by the program directors. Groups vary in size and make-up from year to year without an option to repeat working with the same faculty member. Some past SEEMS research experiences have focused on topics such as: computational thermodynamics and kinetics, polymer science and engineering, petroleum production and engineering, and analyzing ozone production for northeastern United States. At the end of the six-week summer program, each group is required to give a formal 5-10 minute PowerPoint™ presentation highlighting portions of their research.

Recently, an option was added to the Penn State Upward Bound Math-Science program. Instead of having only one venue for conducting authentic science research, students now have two. In 2007, UBMS fostered a new partnership with the College of Science. Participants now can be placed in the SEEMS program or the Summer Experience in the Eberly College of Science (SEECoS) program to conduct their summer research. Some past SEECoS projects cover topics in Astronomy, Chemistry, Forensics, Microbiology, and Physics. Table 3-1 illustrates the 2007 SEEMS and SEECoS projects. Teams marked with an asterisk indicate SEEMS involvement. All other teams fall underneath the SEECoS Program.

Table 3-1: Upward Bound Math-Science SEEMS & SEECoS 2007 Research Teams

Astronomical Clocks in the Sky*
Biodiesel From Vegetable Oil
Climate Change in Africa*
Forensic Ice Age Vertebrate Paleoecology*
Interpretation of Field Observations Collected at Ancient Archaeological Sites in Southern Egypt*
Molluscan body size changes following the Cretaceous mass extinction and during episodes of global warming
Petroleum Engineering*
Petroleum Production Engineering*
Plant Pigments
Polymers and Materials Science*
Satellite Meteorology*
Statistics and the Financial Markets
Summer Research Experience on the Basics of Thermodynamics, Phase Transformations and Diffusion*
The Supernova as a Cosmic Recycling Center
Why ozone pollution is worse on hot days? *

* Indicates SEEMS programs

Having established a relationship with the science researchers and directors of both the UBMS and SEEMS programs through a pilot study conducted in 2006, and considering the newness of the SEECoS program, I chose to work with the SEEMS program for consistency.

Chapter 4

METHODOLOGY

Overview

A Case Study Approach

Qualitative methods have been used successfully in understanding complex social environments. “The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting” (Creswell, 1998, p.15). Case study research is an approach to qualitative research often used by social scientists to examine complex social environments. According to Yin (2003), “A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context especially when the boundaries between the phenomenon and context are not clearly evident” (pg.13). The exclusivity of this strategy of research is that it involves investigating a phenomenon within the context of study, allows for sociocultural interpretation, and allows the use of multiple measures of data collection. Data collection methods often used in case studies range from interviews, observations, records, documents, and audiovisual data within a bound case. This case study examines the nature of the Upward Bound Math-Science (UBMS) Summer Experience in Earth and Mineral Science (SEEMS) research experience. Furthermore, it examines the nature of students’ engagement in their SEEMS research project by investigating the impact of the science research experience on their identity as science learners, participation in the scientific community, and their understandings of the nature of scientific practices within the context of their experiences. Field notes, observations, interviews, and document analysis were among the data sources used to inform the following research questions:

The nature of the SEEMS research experience

A. What are the SEEMS intended outcomes?

B. To what extent does SEEMS enacted curriculum align with the intended outcomes of the program?

The nature of students engagement in the SEEMS research

A. In what ways do students make sense of and apply science concepts as they engage in the research (e.g., understand problem, how they interpret data, how the construct explanations), and the extent to which they use the science content appropriately?

B. In what ways do students engage in the cultural practices of science, such as using scientific discourse, interpreting inscriptions, and constructing explanations from evidence (engaging in science practices, knowing science and doing science)?

Context of the Research Setting

This study was conducted in State College, Pennsylvania, on the campus of The Pennsylvania State University. The boundary of the case used to inform my research questions was the satellite meteorology group within the six-week summer UBMS/ SEEMS program. SEEMS is a unique addition to the TRIO UBMS at The Pennsylvania State University (Penn State).

> The Federal TRIO Programs are educational opportunity outreach programs designed to motivate and support students from disadvantaged backgrounds. TRIO includes six outreach and support programs targeted to serve and assist low-income, first-generation college students, and students with disabilities to progress through the academic pipeline from middle school to post baccalaureate programs. (U.S. Department of Education: Office of Post Secondary Education, 2007b)

TRIO has an extensive history beginning with the Upward Bound Program in 1964 and continuing through the 2001 establishment of Student Support Services. Since its establishment in 1964 eight different types of TRIO programs have been developed.

Upward Bound Math and Science (UBMS) was the seventh TRIO program founded. Its purpose is to service the needs of low income, first generation college students in math and science by providing opportunities for them to see their potential within the field (Research Triangle Institute, et al., 2004). As part of the UBMS program, students are enrolled in classes to strengthen their abilities in mathematics and science courses they will take in the fall following the program. SEEMS, the additional component, is a part of the federal mandate that allows the students who participate in the Upward Bound Math and Science TRIO program an opportunity to participate in science research with a notable university professors at the university location of the program, in this case Penn State.

As previously mentioned in chapter 3, many of the students who participate in the program are from high schools in the area surrounding University Park, Pennsylvania, with the exception of the participants from the Selma Early College High School located in Selma, Alabama. At The Pennsylvania State University (Penn State), students are group with a faculty member in Earth and Mineral Scientist who serves as their faculty mentor and teacher over the six-week period. Students participate in research experiences with their mentors that focus on topics such as: computational thermodynamics and kinetics, polymer science and engineering, petroleum production and engineering, and analyzing ozone production for northeastern United States.

The Role of the Researcher

A significant part of qualitative research is defining the role of the researcher in the study. In doing so, the researcher commits to explaining their perspective or lens, admits to their biases, and defines the many responsibilities they engaged in throughout the research process. This process allows the reader essentially to understand what perspective the researcher offers on both a professional and personal level.

Within the context of this study, my role is the primary investigator. As the primary investigator, I was responsible for all data collection and analysis, and participated as direct observer, interviewer, and evaluator/consultant. In this position, I acknowledged my biases and made every effort to objectively listen and record the information that I observed. When I entered college as an undergraduate, I decided to pursue biology and later medicine. Through my practical experience as a biologist and as an African American woman who initially set out to pursue science as a career I offer a unique perspective. Taking into consideration these viewpoints, I have my own biases towards being academically prepared to pursue science as a career, the enculturation into the science culture, and my understanding of the struggle to gain access into a culture where representation of minorities is sparse. My life experiences as an gender and ethnic minority in science who attended summer research experiences, majored in Biology and minored in Chemistry, and who taught high school biology to other ethnic minorities allows me to critically analyze the data collected in this study. I believe that my personal beliefs about education and how culture, language, and opportunity play a role in the success of underrepresented ethnic minorities and women in science disciplines have helped structure this study. To a fault, these experiences can offer some insight into what the student participants may experience as they participate in the science culture.

Initially, I was recommended for a position with Upward Bound Math and Science (UBMS). At that time, I was unaware of the connection between UBMS and SEEMS. However, to eliminate further bias I opted not to take the position, and instead asked to conduct this study. Thus, gaining access to the program was somewhat effortless. After meeting with UBMS and SEEMS program directors I was able to negotiate my position as a researcher/ observer within the context of SEEMS. The SEEMS program coordinator recommended that I work with a veteran mentor of the study. As such, I contacted the recommended mentor and obtained consent for his participation in this study (See Appendix B). At this time, I explained my role as an observer of his research group and asked if he would participate in a brief interview at the end of the program. My role as primary investigator was not to pass judgment on the teaching techniques or style of the faculty mentor, but rather to objectively collect data and give an account of my observations without prejudice.

Participant observation is a qualitative research technique that has foundations in ethnographic research. Essentially, my role as a participant observer allowed me to view the research participants within the context of their research experience. My role as an observer was not an intrusive one; thus, my involvement can be categorized as *passive participation* (Spradley, 1980). Every Tuesday and Thursday for a period of six weeks, I attended sessions where students met with their SEEMS research mentor for a period of three hours. During this time, I sat in the back of the room or off to the side, videotaped and audiotaped the participants' interactions with their faculty and graduate student mentor, and collected field notes on their daily interactions with their faculty and graduate student mentors. My role as a participant observer was difficult at times. As an educator and researcher there were many times I wanted to interject my opinion during these sessions. However, understanding my role as the primary investigator and how my opinion might bias the environment I did not. Additionally, my role as participant observer was challenging as I tried to attentively record field notes of the students while they were separated into groups of two within the Satellite Meteorology team. These days I opted to take field notes of one group for consistency and would later return to the video to record data of the second group.

Interviewing is another technique often used in qualitative research. Interviewing affords the researcher an opportunity to obtain additional information or to gather information on things not openly observed. Interviews were conducted with each student in the participating SEEMS group, the EMS faculty mentor, and the UBMS: SEEMS program director. Each interview is approximately 15 minutes and focuses on different aspects of the participants' involvement in/with the program. Student participants were interviewed about their experience in the program, feelings about the program, and knowledge about their research. While the faculty mentor and program director were interviewed about the purpose of the program, intended outcomes, and curriculum. As a student of color and having some understanding of the underrepresentation of ethnic minorities and women in science, I found it difficult to interview students about their experience in the program. I consciously tried to suppress my feelings about the success of programs similar to this one. I wanted the students to feel comfortable in responding to my questions. Fundamentally, I believe that my identity as an ethnic minority allowed the participants in the study to feel comfortable with me as the primary investigator. Although a significant age difference exists between the student participants and I, the students showed comfort in expressing themselves in my presence. At times, the students would reach out asking questions about my research and my personal experiences as a teacher and a student.

By virtue of being allowed to work with the UBMS/ SEEMS research program, my role is as an *unofficial* evaluator/consultant. I agreed to share my findings with the program director to highlights areas of high performance and to suggest any improvements needed to improve the program effectiveness for the population of students served.

Participant Selection

Selecting a site in which underrepresented students interact with science proved to be a challenge. Before gathering information about and access to the UBMS/SEEM program, I was unsure of how I would find students that represented members of underrepresented groups in science. According to the 2000 Census, State College, Pennsylvania has a population of 38, 420. Of that number, a subgroup of 37, 814 self-identify with being one race while 606 identify with being two or more races. Within the initial subgroup, 32,392 self-identify with being White, 1,417 self-identify with being Black or African American, 3,368 self-identify with being Asian, 50 self-identify with being Native Hawaiian and Other Pacific Islander, and 529 self-identify with some other race. Acknowledging the demographics of the State College, Pennsylvania, and knowing the population I intended to work with, I had to find an alternative way of incorporating members of underrepresented groups in science this study.

The geographic area of State College, Pennsylvania, is relatively remote and does not have a very large population of secondary students who are members of underrepresented groups in science. As a result, participants in this study were selected because of access, availability, and locale. The UBMS program provided an avenue by which a number of African Americans and Hispanic students from surrounding areas in Pennsylvania travel to The Pennsylvania State University for a six-week summer experience that had a *science research component*. The fact that this program brings a large minority high school population to the State College area and affords these students an opportunity to work with leading researchers in the Earth and Mineral Sciences was ideal for my research.

The number of students that participate in SEEMS varies from year to year. Each year the program brings as many as ninety participants to Penn State for the summer. Upon requesting to work with UBMS/SEEMS for my dissertation, reputational-case selection was employed as a means of selecting the faculty mentor in the program. As previously mentioned, it was recommended by the SEEMS coordinator that I work with a veteran mentor of the study. Students are randomly assigned to mentors they work with each summer; ergo, the suggestion of a mentor rendered the student participants for my study.

My initial involvement with SEEMS began in the summer of 2006. As I prepared to conduct the study, I learned that the paring of students with mentors depended upon their interest as reported before enrollment in the summer. The assignment of students to mentors relied on the request provided as their first choice for the research experience, giving priority to rising seniors and without an option to repeat having the same mentor twice. My attempt to collect data from the 2006 Meteorology team was unsuccessful; the sound on the video data collected was inaudible. Thus, the data collected from this trial was inadmissible in this study.

The summer of 2007 marked my second attempt to conduct my study. Learning from the mistakes in my pilot study, I was able to secure microphones, multiple cameras, and iPods™ to make certain that the audio would be clear for transcription and as a fail-safe method of obtaining the conversations of the students in their groups. In my second pass of collecting data, one of the students assigned to the group was also in the group I observed in 2006 during my pilot study.

Participant Recruitment Procedures

Obtaining consent or assent from participants is a major part of working with human participants. This is a formal manner where the primary researcher solicits the involvement of participants while explaining who he/she is as the researcher, the purpose of the study, procedures, personal and societial benefits, and expectations of study participants. Strict guidelines are set in place to protect research participants at The Pennsylvania State University. Parental consent must be obtained for *all* children.

> Under Pennsylvania law, persons under the age of eighteen (18) generally meet this definition of "children", with the exceptions noted below. As a result, permission of the child's parent(s) or guardian(s) must generally be obtained prior to the participation of that child in research. The following exceptions to the general rule apply, where a person under the age of 18 does not meet the federal definition of "child" and may provide legally effective consent to participate in research if either:
>
> 1. The research involves the provision of medical care or treatment, (including care or treatment deemed to be experimental) AND the person:
>   a. has graduated from high school, or
>   b. is married, or
>   c. is or has been pregnant.
> 2. The person is an emancipated minor.
>
> (The Pennsylvania State University Office for Research Protections, © Copyright 2005-2009, The Pennsylvania State University)

Participants who are not considered children only have to sign consent forms if they agree to participate in a research study. Participants who are considered children must obtain both consent and assent to participate in a research study. Signed copies of the assent forms are kept on file with the primary researcher in a binder with other important documents relative to this study. For reasons that will be further explained in the subsequent paragraphs, consent forms were only kept if they were returned.

Parental Consent

I obtained the home addresses of each of the Satellite Meteorology team participants from the UBMS program director. Prior to the study, participants' parent(s)/guardian(s) received an invitation asking them to consent to allowing their child to participate in this study (See Appendix E). Two copies of informed consent were sent via mail providing necessary information detailing their child's involvement in this study; both copies were signed and dated by the primary researcher. For the sake of consistency with other program consent documents parent(s)/guardian(s) were instructed to return one signed copy of the opt-out form back to the primary researcher within one week of receiving the information about the research if they ***did***

not wish to allow their child to participate in the research (See Appendix F). Self-address stamped envelopes were provided**.**

Initially it was proposed that I would send consent forms to the student participants' parent(s)/guardian(s) information regarding the study via mail with both copies signed and dated by the primary researcher. The directions instructed participants parent(s)/guardian(s) to sign and send back one copy of the consent document using the self-addressed stamped envelope provided if they were in agreement with allowing their child to participate in this study. The letter also suggested that they retain the additional copy for their records or should they have any questions.

One of the SEEMS directors and Institutional Review Board (IRB) officer suggested an alternate plan to obtain parental consent by sending out a joint consent form with another research team who was already awarded IRB approval, adding the information for my study to the form to avoid sending parents duplicate paperwork. However, neither the initial nor the alternative plan worked. The other research team that was working with the SEEMS program had already sent out their consent forms, and in my efforts to be consistent with documentation the program already had in place, it was suggest that I use the opt-out consent method the same approach the other research group utilized.

Student Assent

Prior to the study and after opt-out consent a period of two weeks passed allowing enough time for the opt out forms to be returned from parent(s)/guardian(s), I introduced the student participants to the study using a script inviting them to participate (See Appendix C). All logistics of the study were explained, noting that participation is not mandatory. Assent forms were given to those student participants whose parent(s)/guardian(s) who did not opt-out of having their child participate in the study. Two copies were provided for each student, again one for the researcher and the other to be retained by the student participant. All four students in the research group I observed agreed to participate in my study. Table 4-1 provides demographical information for the student participants.

Table 4-1: 2007 Satellite Meteorology Participant Demographics

Participant	Grade Level*	Gender	Age	Hometown	Race/ Ethnicity	Number of Years in the Program
Althea	Junior	Female	15	Reading, PA	African American	2
Calvin	Senior	Male	18	Reading, PA	Hispanic	1
Sharon	Junior	Female	16	Reading, PA	African American	1
Yvette	Junior	Female	15	Harrisburg, PA	African American	2

*Grade level indicates upcoming school year

Adult Consent

The Pennsylvania State University faculty (science researcher), staff (program director), and graduate student participant (assistant researcher) were given a detailed explanation of the nature of the research experience and what was expected of them as participants, noting that participation was not mandatory. Two signed informed consent forms were provided, one to be retained by the participant and the other to be retained by the primary researcher (See Appendix B). Consent was obtained from the faculty mentor, assistant program director, and graduate student mentor.

Data Collection Procedures

Sources of Data

Multiple sources of data can greatly influence the amount, view, and direction the researcher has on a study. When mapping out what data sources to employ in a study the researcher has a lot to consider. Choosing data sources that will best inform the research questions is imperative in this process.

In qualitative research data collection methods often used include collection of field notes from direct observation, interviews, review of documentation, participant observation, and others. The use of multiple data sources adds strength and helps accentuate the findings of the study. This support and iterative process is called triangulation in qualitative research. Triangulation can be equated to a cross checking system that supports/adds strength to the researcher's findings, or negotiates a thought or observation based on the lack of evidence.

The planning and selection process of how and what data sources to use is an important one. Creswell (1998) shows that in case study research the typical forms of data include documents and records, interviews, observation, and physical artifacts. A number of these data sources were used to respond to particular research questions in this study. Table **4-2** gives a brief overview of each of the research questions guiding my study and aligns data sources and artifacts used to inform each question.

Observations

Observation is a fundamental and highly important method in all-qualitative research (Marshall & Rossman, 2006, p. 99). There are several types of observations with varying degrees of involvement. These different types of participation vary from being immersed into the culture completely to nonparticipation (Spradley, 1980). This category of data collection seems simple, however it is a researchers' first look at the participants in the natural setting of the research lab and where the researcher forms his/her first impressions. Observations recorded as field notes gave a brief overview of what the researcher observed detailing information about the major/reoccurring events and behaviors of the participants within the research setting. Marshall & Rossman (2006) explains that these notes or recordings can range from detailed accounts or checklist of behavior.

Table 4-2: Research Questions & Artifacts.

Research Questions	Data Sources & Artifacts
What is the nature of the SEEMS experience?	
What are the SEEMS intended outcomes?	Interview with Program Director and SEEMS Mentor Document analysis of intended curriculum Promotional material U.S. Department of Education Funding Documents
To what extent does SEEMS enacted curriculum align with the intended outcomes of the program?	Video and Audio Recordings of students and mentors within their SEEMS groups Direct observation and field notes Day to day observations of (actual) experience
What is the nature of students engagement in the SEEMS research?	
In what ways do students make sense of and apply science concepts as they engage in the research? (e.g., understand problem, how they interpret data, how the construct explanations), and the extent to which they use the science concepts appropriately?	Video and audio recordings Student presentation: text of PowerPoint™
In what ways do students engage in the cultural practices of science, such as using scientific discourse, interpreting inscriptions, constructing explanations from evidence? (science practices, knowing science and doing science)	Data: audio and video recordings, field notes Student presentation: text of PowerPoint™

This is an important yet tedious task, as it requires the researcher to be highly organized, detailed in his/her account of what occurred, and focused while within the nature of the phenomenon studied.

As it pertains to this study, observations were recorded in an Excel™ spreadsheet (See Figure 4-1) to keep record of the daily accounts of what happened within the SEEMS research group. To help with organization of the data collected I used column headers. These included a column that specified time in ten-minute increments, a column to describe what action took place during the specified time, and a column where I included any of my notes as the researcher. I combined the data collected during my initial observations with video descriptions to ensure accuracy except in those cases when a second group was established. Furthermore, I used these notes and detailed accounts of the daily happenings within the SEEMS research group as a guide to determine incidents that might inform my research. In total, I collected *fifty-two* pages of observation/video notes.

Double-click to add header

Time	Description	Notes
00:00-00:10	Opens with the objectives and summarizes what has already been done. Last half of week four. The group has done a buch of plots and regression lines and they have the correlation coeiffecients r2. So they are well into the stats and then starting to think about just one variable at a time to explain cloud height can we do more than one vairable at a time to try and get a higher percentage of the result explained. Next week they will try to get to a physical understanding and try to get to what they are going to present So they are moving through the crust of the science. Questions are they ever getting clouds over Everst? Dr.Everest says that they will have to look back at the notes to review this information Dr. Everest leads the setting up of the Excel spreadsheet that will compute the information that the students have collected Dr. Everest takes over with trying to set up the Excel spreadsheet for a brief time so that he can separate them the way he wants them. Then he dictates what it is he needs inputed into the cell. Follows up with explaining what purpose this serves. Sharon spends time copying the formula into all of the cells.	Dr. Everest looks over the material and goes over the days regiment and summarizes what has already been done.
00:10-00:20	Sharon is still copying and pasting the formulas from the cells. Dr. Everest explains: Linear regression means I am going to take a fudge factor as each of the predictors add them all up and try and get the answer, He then attempts to explain the information to the group with an analogy. Carla makes the notes on the board and Dr. Everest proceeds to look back at the pictures. Using the information from the spreadsheet, Dr. Everest attempts to explain regression to the students and how it will be applied to their project Dr. Everest attempts to have EXCEL compute the regession.	Here Dr. Everest seems to be talking to the students, but they don't seem engaged.

Figure 4-1: Field Notes

Interviews

"Although you could gather important data, even as spectator you would not know the feelings and perceptions of a participant" (Spradley, 1980, p. 51). As previously stated, interviewing affords the researcher an opportunity to obtain additional information or to gather information on things not openly observed. Interviews, in this study, provided an in-depth look a key points that are directly linked to my research questions and helped ascertain the participants' knowledge about their involvement in the program and how they saw themselves within the research group/community. My initial proposal stated that student participants would participate in a series of audio taped interviews and focus groups. The proposal also stated that interviews would be conducted of the UBMS program directors and science faculty mentor with possible follow-up via email in an effort to draw out what they feel the nature of the SEEMS research experience. Interviews were conducted with each of the selected SEEMS group participants and SEEMS faculty mentor at the end of the program (See Appendix G and Appendix H). In lieu of an interview with the UBMS/SEEMS program director, paper proceedings from the 2005 Women in Engineering ProActive Network (EPAN)/ The National Association of Multicultural Engineering Program Advocates, Incorporated (NAMEPA) joint conference that talks about the SEEMS high school bridge program was used.

Patton (2002) illustrates three different types of interview strategies. These include the informal conversational interview, general interview guide approach, and the standardized open-ended interview. Of the three approaches, standardized open-ended interview applied to this study. This style of interviewing is guided with a set of a priori questions, the researcher still plays an integral role in the interview with regards to what type of follow up questions will be asked if the participant is ambiguous or if the participant says something that would require an in-depth look. The selected interview questions were apart of a structured protocol constructed so that participants would feel compelled to engage in a conversation beyond a simple yes or no response. Participants were encouraged to treat the interview process as a conversation to ease their anxiety and to make them comfortable with the discussion. Each interview was recorded with an iPod™ or voice recorded. These files were transferred from the device used and saved onto an external hard drive for storage. All interviews were transcribed and the transcript saved onto the same external hard drive with the participants name and the date of the interview for further analysis. Each interview was transcribed using Express Scribe™ transcription and playback software (See figure 4-2) and a professional two pedal foot pedal by VEC simultaneously. Thirty-one pages of transcripts were later transferred into Microsoft Word™ in a chart formation with designated speaker parts identified (See Figure 4-3)

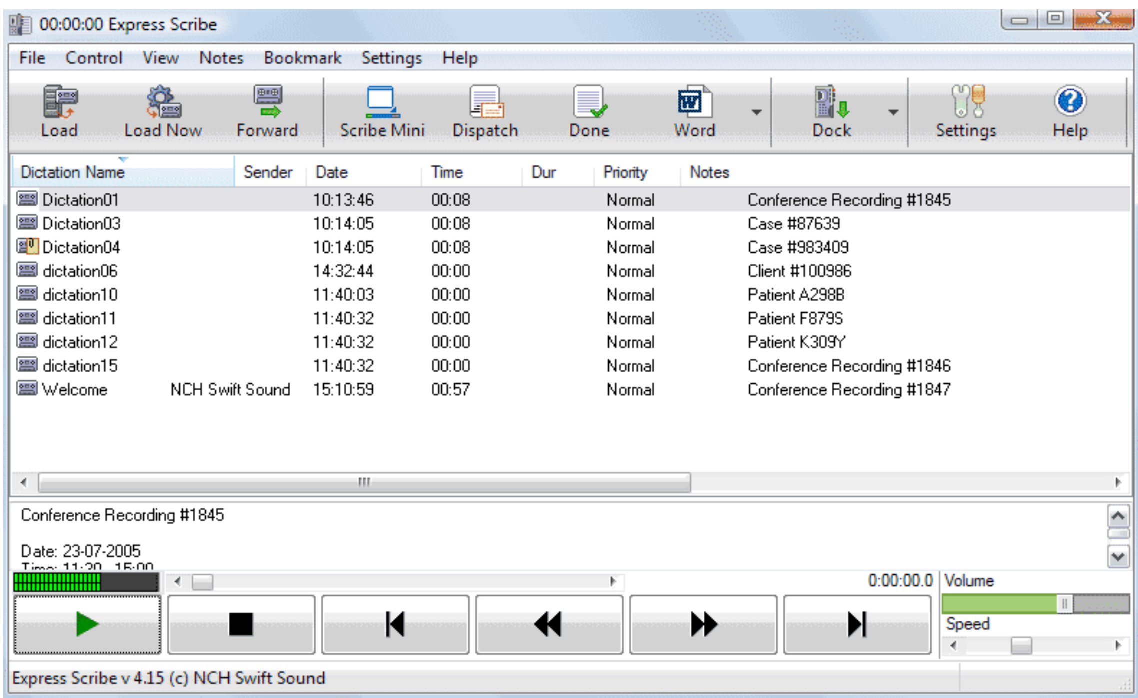

Figure 4-2: Express Scribe™ Playback Software.

Interview Transcript
Annette, 15
Reading High School
Reading, Pennsylvania

PI	Okay, so what year is this for you in the SEEMS or UBMS?
Annette	This is the second year
PI	This is your second year?
Annette	yes
PI	who did you work with your first year?
Annette	umm, I do not remember his name it was a graduate student
PI	okay, you remember the project
Annette	umm in seismic base mine void detection
PI	Wow! What does that mean?

Figure 4-3: Interview Transcript.

Documents

SEEMS is federally funded program, and as a result a number of documents were used to promote this program to participants. "Records, documents, artifacts, and archives –what has traditionally been called 'material culture' in anthropology—constitutes a particularly rich source of information about many organizations and programs" (Patton, 2002, p. 293). Reviewing archival documentation can assist in incorporating background information from a historical and contextual lens (Marshall & Rossman, 2006). In this case, these sources provided a historical look into the program and background information about the development and target audience.

A historical overview of the program can be found on the U.S. Department of Education's website in the form of booklet entitled a Guide to U.S. Department of Education Programs. This is representative of official document that gave insight into the foundation of what TRIO is and the types of projects that have been developed as a result of its inception. Furthermore, it categorizes what type of program UBMS: SEEMS is in the grand scheme of educational development. Historical perspectives and other relevant information obtained in reviewing the programs promotional material and guidelines for a funded proposal allowed for an in-depth look at what the program was advertised as. These documents allowed a comparative analysis of the advertisement (intended curriculum) with the enacted curriculum. Review of these documents also provided more information about who qualifies for the program and logistics behind what keeps the program in existence.

Information regarding the UBMS and other federally funded programs was obtained in the form of brochures and booklets from the U.S. Department of Education and later converted into a chart that illustrates the year each program was implemented, the program name, and a brief description of each (See Appendix N). Also, documentation about UBMS and other TRIO programs were printed from the website for further analysis. Information regarding Penn State's program was obtained for the SEEMS program director and UBMS website as it pertained to the SEEMS program. All documents were categorized and stored for further analysis.

The faculty mentor's lesson plan is another piece of documentation that was collected for analysis. The data from this document was used as a measure to evaluate whether or not the objectives of the program as stated in by the program directors, publications, and faculty mentors were met. Information regarding the objective of the research project and a detailed account of the student participants' daily activity was listed on a webpage the faculty mentor developed for the students as a way to track their progress with the project. This information had remained available online and can be accessed at anytime. There was no particular storage technique implemented with this form of documentation as it remains readily available online.

Survey is another form of data collection that can be categorized as a form of documentation. Survey data, although used primarily in quantitative research, can add validity to qualitative research as well. A pre and post survey is administered to the students of the UBMS/SEEMS program each year (See Appendix I and Appendix J). The pre-survey was administered the first day of the program prior to the group assignments. The post-survey was administered at the end of the program, before the students left for home if time permitted.

Survey data collected was used primarily for descriptive statistics and to obtain other general information. Both surveys were collected and given to the Earth & Mineral Science SEEMS director who hired a team of graduate students to input and run the analysis of the data.

During the development of the instrument for the 2007 UMBS/SEEMS class I was allowed to place a few items on the instrument that would help answer my research questions. Using a Likert scale, the statements found in Table 4-3 were inserted as part of the pre-survey instrument. A Likert scale is the primary measure for the questions on the questionnaire and for consistency I opted to use the same method. These questions were added to survey what each student thought about their identity and science. Furthermore, questions were also added to assess students' experiences in their high school science classes.

Table 4-3: Items Added to Pre-survey Instrument.

Questions	Likert scale				
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
I can see others or myself like me as a scientist					
Science difficult for you					
Scientist work together as a team					
Scientists / doing science is isolating					
Science research requires coordinating results from multiple studies					
My high school experiences with science has been primarily through worksheets					
My high school experience with science has been through a hands on approach					
I have had an enjoyable high school science experience					

The survey instrument was not included in my analysis. When negotiating to enter these items on the instrument, I assumed that they would be entered on both the pre and post survey instrument. Instead, they were entered only on the pre-survey. Thus, results from this data source are representative of all students enrolled in the UBMS/SEEMS program at the start of the program. Instead of using this data source, I used the data from the student participant interviews to address these questions, as these items were included in the interview protocol (See Appendix G).

Video and Audio Recordings

Over time the use of video and audio recordings has become an integral part of qualitative research (Patton, 2002). "Film has the unique ability to capture visible phenomena seemingly objectively…"(Marshall & Rossman, 2006, p. 120). However, the field of view or lens at which the observer visualizes heavily relies up the filmmaker. Video and audio taped proceedings gives the researcher an advantage to revisit things that may not have been recorded in field notes, provides a level of accuracy not provided in the collection of field notes, and provides the researcher with a better opportunity to revisit episodes within the of the study.

The participating groups' interactions while they were engaged in the research experience with the science researcher/mentor, group members, and graduate student participant assigned to the group were videotaped using mini digital videos. Initially students worked in what I have termed "whole group" setting. However, the group structure would often vary according to the daily objectives. Based upon involvement during my pilot study, I was aware that the faculty mentor might break up the group of students to allow them to work in smaller groups so that the maximum amount of data could be gathered or to maximize the use of time towards the completion of the group's PowerPoint™ presentation. Two cameras were strategically placed to capture the student participants' interactions with one another and the mentor present during these instances. Approximately seventy-two hours of video/audio data of students' interactions within the research group were collected, converted to DVDs, transcribed, and analyzed.

Apple iPods™ were used as a precautionary measure to capture audio of these everyday proceedings in the event that there was device failure with the camera microphones used. Procedural breaks were given to the students, and at this time a new tape was used to eliminate breaks within the record. Videotapes were labeled detailing information about the group's setup, the sequential order in which the tape should be played, date, and year of the program. The tapes were stored in a large plastic bin and kept in a locked area. Each taped was later compressed and transferred to a DVD as QuickTime™ movie using Apple iMovie HD™ (See Figure **4-5**). DVDs were labeled and organized by day and group. All tapes from day one were compressed and saved on one DVD separated by group, but in sequential order. Each DVD made was transferred and stored in a protective CD case until further analysis was needed. Video playback and analysis was initially conducted using Studiocode™ video analysis software (See Figure **4-6**). Studio code was also used to develop the initial coding window later used for video and audio analysis (See Figure **4-7**).

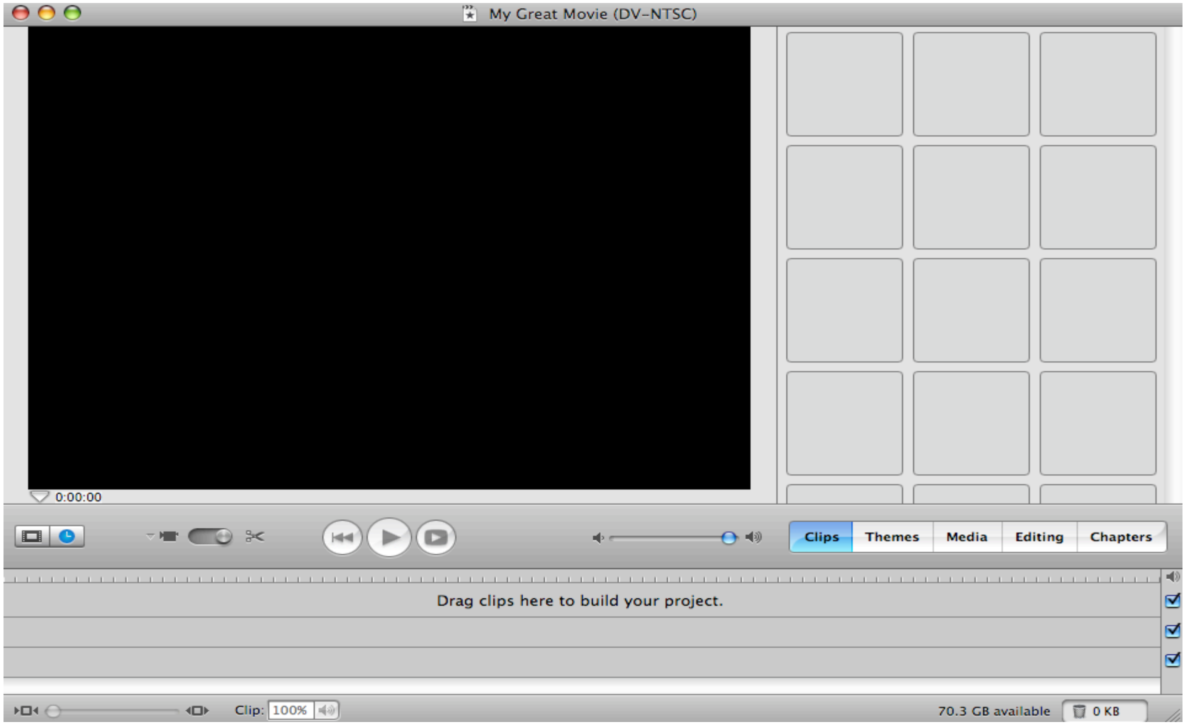

Figure 4-5: Apple iMovie HD™.

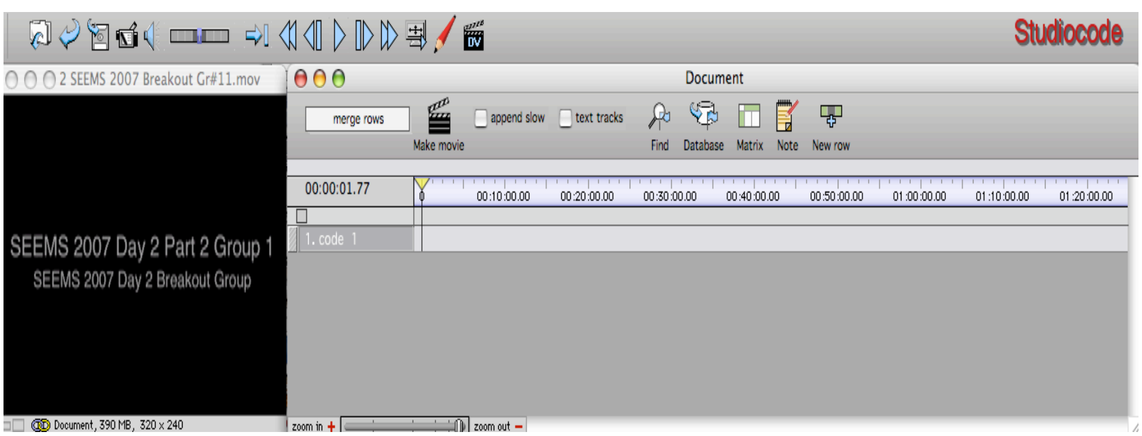

Figure 4-6: Studiocode™ Video Playback Window.

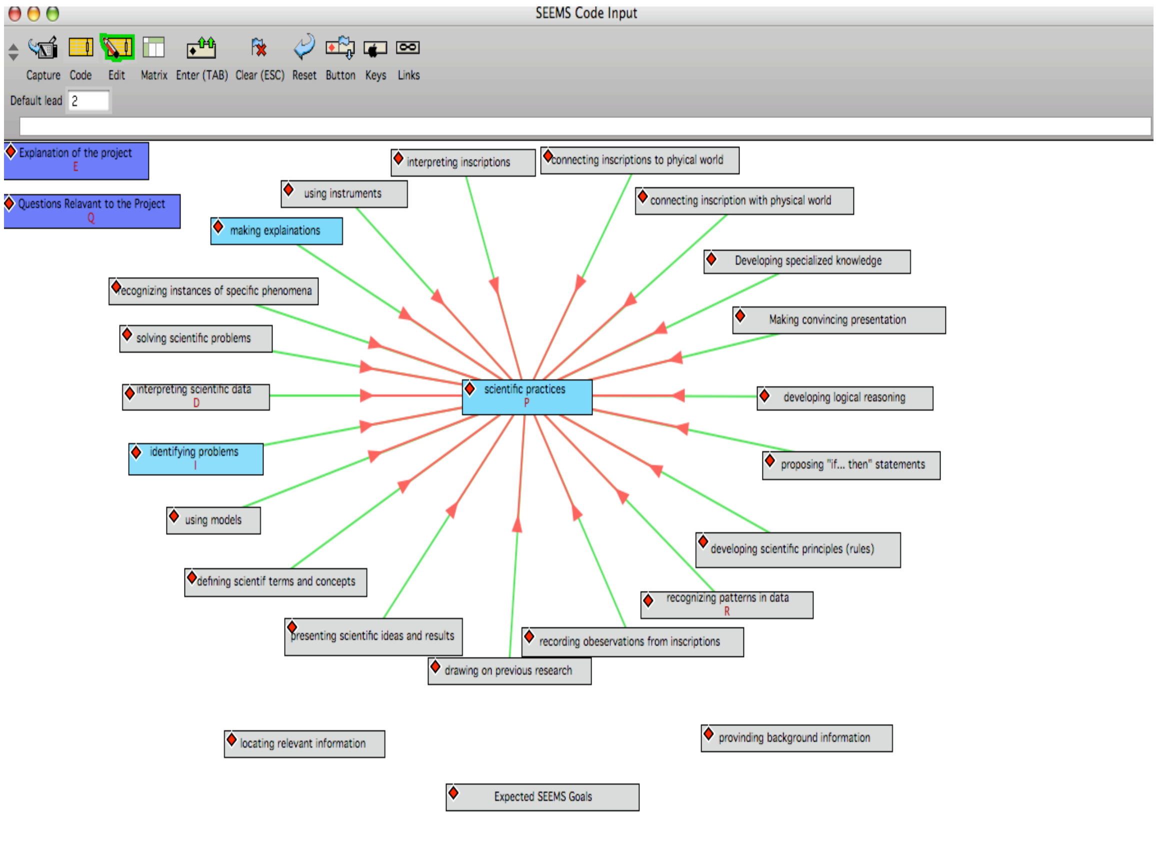

Figure 4-7: Studiocode™ Code Input Window.

Finding a transcriptionist who was proficient in Studiocode™ was difficult. Two transcriptionists were hired and worked simultaneously on the data. Both used QuickTime™ and Microsoft Word™ to view and transcribe the video respectively. After deciding not to use Studiocode ™, the coding scheme was developed using an Excel™ spreadsheet.

Data Analysis Procedures

UBMS: SEEMS documents, pamphlets, and webpage were examined for information relevant to the research questions about the nature of the SEEMS experience. Specifically, those questions that focused on the intended SEEMS outcomes. These data sources were used primarily to provide information about the history of the program and determine the overall objectives of the UBMS: SEEMS initiative. An informal conversation with a representative at the United States Department of Education provided insight in the program's background and purpose. Although this conversation was not recorded as a data source the information provided was confirmed in the documents received.

Grounded theory is a methodological technique developed by sociologists, Barney Glaser and Anselm Strauss. Unlike traditional research methods, "the grounded theory approach is a qualitative research method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon"(Strauss & Corbin, 1990, p. 24). In other words, grounded theory is not based in pre-developed ideas or theory. The researcher sets out to explore the data sources to discover recurring themes that he/she categorizes as they emerge. Using multiple data sources, the researcher seeks to find relationships and reoccurring themes that might generate a theoretical claim. Applicable to both qualitative and quantitative research, the basis of grounded theory requires the constant comparative analysis and saturation of data throughout the study (Creswell, 2003). The researcher simultaneously analyzes data and establishes codes to categorize events or phenomena that emerge from the data sources. Each code that is established is defined and compared to similar codes to ensure consistency and to establish *conceptual density* (Strauss & Corbin, 1999). Broader categories are established and codes are grouped and categorized throughout the coding process. Once the emergent theory is identified, the researcher validates connections thus establishing the emerging story from the data.

Three forms of coding are commonly associated with the procedural techniques used in grounded theory methodology. These include open, axial, and selective coding. Open coding is used to delineate initial stages of the analytic process. It is an important piece of the coding process because it describes the incidents, events, and themes within the data source. According to Strauss and Corbin (1990), "[o]pen coding is the part of analysis that pertains specifically to naming and categorizing phenomena through close examination of data" (p.62). Axial coding generally follows the open coding process of analysis, however, toggling between the two techniques is not uncommon (Strauss & Corbin, 1990). Axial coding is a part of analysis where the researcher begins to establish connections within the broader categories structured during open coding. This verification method is known as a paradigm model. This technique establishes conceptual density within the context of the research and helps to substantiate analysis. Selective coding is the final coding technique used in grounded theory methodology. It is the coding process where "the researcher identifies a 'story line' and writes a story that integrates the categories in the axial coding model" (Creswell, 1998, p. 57). The selective coding process further substantiates relationships that became apparent during axial coding, and theoretical categories begin to emerge. Drawing connections between categories and subcategories, the researcher begins to construct themes grounding these assertions within the data sources.

Data analysis, in this study, began the first day the SEEMS Satellite Meteorology team met. As previously mentioned, field notes were collected of the group's daily interactions. These fieldnote records were recorded on a laptop computer, with ten-minute increments marked for organizational purposes. These notes focused on the exchanges of the group with the faculty or graduate student mentor. Following each session, I would review the video of the daily activity combining my field notes and video notes from the day. Within the context of my analysis, I began with the establishment of preliminary codes, following the grounded theory approach. Preliminary codes were established to define incidents that emerged throughout my initial analysis and appeared to have some theoretical relevance to my research questions (See Appendix K). For example, from the research questions that focused on the nature of students engagement in the SEEMS research codes defining engagement in scientific practice were developed to identify key instances within field notes and video analysis. These key events or happenings along with my researchers' notes served as markers within the data signifying areas I should revisit for further analysis.

Following the grounded theory approach, I took notes about the events that could be used subsequently for theoretical or purposive sampling. According to Strauss & Corbin (1999), "theoretical sampling is sampling on the basis of concepts that have proven theoretical relevance to the evolving theory" (p. 176). Furthermore, Merriam (1988) defines purposive sample as sampling, "… based on the assumption that one wants to discover, understand, gain insight; therefore one needs to select a sample from which one can learn the most" (p.48).

The coding process employed throughout this study was an intensive and comprehensive one. Multiple passes at the data sources were employed to exhaust the possibilities of new codes. Further analysis of the preliminary codes resulted in renaming, grouping, and regrouping of similar codes, and the establishment of properties. Upon further analysis, properties were arranged into broader groups or categories (See Column #1 Appendix K and Table **4-4**).

Throughout the axial coding process, a preliminary model was established which allowed me to review key incidents/events within the study to ascertain casual relationships, contexts, exchanges, and consequences in which the incidents/events occur.

Triangulation

The coding process served as a system of constant checks and verification among multiple data sources. This support and iterative process is called triangulation in qualitative research. Triangulation can be equated to a cross checking system whether supporting, adding strength to the researcher's findings, or negotiating a thought or observation based on the lack of evidence (Creswell, 1998, 2003; Denzin & Lincoln, 2003; Patton, 2002). The use of multiple sources of data can greatly influence the amount, view, and direction of a study. Choosing data sources that will best inform the research questions is imperative in this process. In qualitative research the angles or data collection methods often employed will include collection of field notes from direct observation, interviews, review of documentation, participant observation, and others.

Table 4-4: Coding Scheme

Practices (Pedagogical or Scientific)	Code Name	Definition/Criteria
	Analyzing data	Scrutinizing, reviewing and responding to anomalous data using Excel[a]
	Collecting data	Gathering, recording, and making intelligible decisions on cloud types and location
	Constructing explanations	Using data and background information to respond to questions about the project
	Making assertions	Using inductive and deductive reasoning to ascertain how/what the findings are
	Making sense of the problem	Generating questions to clarify points related to the project
	Publishing	Organizing data/results to be presented Preparing PowerPoint presentation
	Using inscriptions	Applying the use of cultural expressions of science relative to Satellite Meteorology appropriately (ie. identifying cloud types, latitude, longitude).
	Using instruments	Using scientific instruments relevant to the cultural practices of Satellite Meteorology to engage in the science research experience. (i.e., MODIS, Google Earth)
	Addressing limitations	Explanation of limitations associated with using instruments
	Defining terminology	Defining key terms (i.e., remote sensing, photogrammetry, and types of clouds)
	Introducing instruments	Instructing students on how to use scientific instruments
	Making connections	Making connections to real world application
	Providing background information	Presenting background information on key concepts, theories, and/or formulas related to the research project. Defining goals and objectives of the project.
	Providing explanations	Clarifying information using illustrations, visual aids, and analogies.
	Reinforcing and Preparing	Suggesting homework Testing students' knowledge of concepts, terminology, understanding.
	Responding to questions	Responding to questions posed by students about background information

Using multiple data sources in this study strengthened and accentuated the connections between the categories and themes, thus triangulating the assertions that emerged from the data. As illustrated in Table **4-2** multiple data sources were used to add depth to each of my research questions. Each of my proposed research questions was supported by a number of artifacts or data sources to ensure consistency and accuracy within my findings.

Program documents were used to provide information about the intended outcomes and purpose of the program. Interviews were used to confirm the accuracy and to eliminate researcher bias of student involvement in the research group and understanding of the science. For consistency the following data sources were cross-referenced with one another to ensure accuracy: field notes, audio/video data, video transcripts, interview transcripts, and program documentation. Field notes contained comments and codes that were used to mark instances within the enacted curriculum that were identified as important at ten-minute increments. After reviewing those instances in the field notes that were deemed significant, a review of the video/audio data and transcript was done to make certain that the findings were accurate. Those instances that were deemed significant were recoded for possible use as evidence within the analysis chapter of this dissertation.

Limitations

Acknowledging the limitations in this study provides me an opportunity to address those areas of weaknesses and bias within the context of my study. Furthermore, it allows me an opportunity to scrutinize my own work to show professional growth and discernment within the field.

First, I think that is important to note my role as the primary researcher in this study. Although it was discussed in great detail in the role of the researcher's section of this chapter, it should be noted that as the primary researcher my biases serve as both strength and limitation. The professional and personal insight that I bought to this study gave me an advantage in knowing what information was relevant to my research questions as it pertained to the participants of the study. Coincidently, this same strength doubles as a limitation. The professional and personal insight that I had prior to the study might have hindered my outlook and analysis of the data. However, I feel that this limitation was minimized as a result of the methodological techniques and procedures used in the study. Although my biases may be prevalent, grounded theory eliminates some biases with the verification and coding system that substantiates findings grounded in multiple data sources.

Second, I wish to acknowledge the absence of the survey data as a limitation in this study. As a result of a miscommunication, the survey data was not included as a viable; this data source would have provided information about the program and its participants in general. Though an important piece in qualitative research, the absence of this data source was countered by the abundance and variety of data sources used which require unique and varying approaches to analysis.

Third, I acknowledge the limitations of the sampling procedures used and the sample size. Theoretical/purposeful sampling was the sampling strategy used in this study. Thus, I acknowledge that the findings of this study cannot be generalized to all underrepresented student groups in science. Furthermore, the sample size of the participants compared to the broader perspective of the program is another limitation associated with sampling. Compared to the total number of students enrolled in the UBMS/SEEMS program, committing time to observing one group limited the perspective of the study. The strength in observing only one group is that I have an information-rich case that offers an in-depth look of one account, instead of having a shallow account of multiple cases. By limiting the study to one research group, I was able to collect in depth information about the enacted curriculum and see first hand how the students participated within the research setting. However, had I chosen to work with multiple groups, I would not have had the same experience. As the primary and only researcher on the project over extending myself to meet the demands of audio and video recording more than one group would not have allowed me to study a particular group at length. Field notes, which provided insight into key incidents from the enacted curriculum, would have been unreliable and imprecise. To some extent, the restrictions placed on this study because of the limited personnel allowed me to work closely with one group where I was able to build a bond with the faculty and graduate student mentor, and gain the trust of the student participants. Furthermore, by limiting the study to one group I was able to saturate the data sources and artifacts collected.

Finally, another limitation is the potential for bias introduced by the use of observational data. Observations are often limited based upon the researcher's involvement in the context of the setting. Although I was a passive participant in the study, I must recognize the possible effect that my presence or the presence of the cameras or iPod™ had on the participants' involvement or interactions. Complimentary to this are the limitations associated with using interview data. I must acknowledge also that only one interview was conducted with the each of the participants in the study. Multiple interviews could have added depth to the findings of the study. An additional limitation associated with the interview data in this study is the context in which the interview occurred. The program schedule kept the students constantly involved; thus, arranging time to meet with the student participants proved to be a difficult task. With all other scheduled daily activities the students participated in, it was difficult to arrange a time to meet with each student in a secluded setting where I could conduct the interview. As a result, the interviews were conducted towards the end of the program and on a day when students were transitioning between activities.

Chapter 5

ANALYSIS AND RESULTS

The focal point of this study is the student participants and their experience in the 2007 Summer Experience in Earth and Mineral Science (SEEMS) Satellite Meteorology team headed by a faculty member in Earth and Mineral Science (EMS) at The Pennsylvania State University. This chapter will address the central research questions related to the nature of the SEEMS research experience and the nature of the students' engagement in the SEEMS research. The chapter is organized using the research questions:

The nature of the SEEMS research experience

A. What are the SEEMS intended outcomes?

B. To what extent does SEEMS enacted curriculum align with the intended outcomes of the program?

The nature of students engagement in the SEEMS research

A. In what ways do students make sense of and apply science concepts as they engage in the research (e.g., understand problem, how they interpret data, how they construct explanations), and the extent to which they use the science content appropriately?

B. In what ways do students engage in the cultural practices of science, such as using scientific discourse, interpreting inscriptions, and constructing explanations from evidence (engaging in science practices, knowing science and doing science)?

Recall that documents from the United States Department of Education (DOE), promotional material, interviews, field notes, and audio and video recordings were used as data sources for this study. While all artifacts contribute to the findings of this study, video and audio recordings of the research component of the Upward Bound Math-Science (UBMS)/SEEMS program was the primary source of data.

Participants in the Satellite Meteorology team met twice weekly for three hours. Within the team, students were sometimes divided into groups of two facilitated by the assigned EMS faculty member or his graduate student. Using a proposed project outline (See Appendix L), participants engaged in day-to-day activities to meet the intended objectives developed by the EMS faculty member.

The Nature of the SEEMS Research Experience

Table 5-1: The Nature of the SEEMS Research Experience

What are the intended outcomes?
To what extent does SEEMS enacted curriculum align with the intended outcomes of the program?

What are the intended outcomes?

As science, technology, engineering, and mathematics (STEM) disciplines continue to grow there is a need increase the number of students who can successfully matriculate in these fields (National Research Council, 1996, 2007). Thus, it is essential that science education evolve to support this ever-broadening perspective by increasing science literacy among all students. In particular, there is a need to increase the representation of ethnic/racial minorities and females in these fields (American Association for the Advancement of Science, 1994; O. Lee & Luykx, 2006; Oakes, 1990). The 1990 establishment of Upward Bound Math-Science (UBMS) was created in an effort to respond to the numbers of individuals identified as underrepresented in the STEM disciplines (Research Triangle Institute, et al., 2004). In an effort to examine the intended outcomes of the SEEMS program, I first provide the overall objectives of both UBMS and SEEMS. Though the primary focus of this study concentrates on the SEEMS experience, it is important to provide the objectives of the overall UBMS initiative to show the relevance of the SEEMS experience as a whole and how it fits into the intended outcomes of the TRIO programs.

The Department of Education (Research Triangle Institute, et al., 2004) sites two important goals of UBMS:

> (1) to foster increased math and science educational participation to prepare a U.S. work force able to address the scientific and technological issues and problems of the 21st century, and (2) to increase the representation within the math and science fields of persons from low income and minority backgrounds, and of persons who are in their families' first generation to obtain bachelors degrees. (p.1)

Specific to The Pennsylvania State University, The Office of the Vice Provost for Educational Equity reports, "The purpose of the Upward Bound Math and Science Center (UBMS) at Penn State is to assist participating students in recognizing and developing their potential to excel in math or science and to encourage them to pursue postsecondary degrees in these fields" (The Pennsylvania State University: Office of the Vice Provost for Educational Equity, 2009a). Both the federal and institution specific objectives of UBMS illustrate an established program that services the needs of underrepresented students in the areas of math and science. SEEMS, a sub-component of the UBMS program, focuses on providing participants an opportunity to participate in research within the EMS disciplines. According to Markley and Fail (2005), SEEMS functions to

> introduce a model of research integration into the curriculum that can be used as an on going method to strengthen problem-solving ability and develop critical thinking, observational, and communication skills. Specific focus will be placed on implementing research curricula that follow best practices for equipping students to transition to post secondary education, as well as the use of relevant research topics and innovative resources and technology to "level the playing field" for students coming from resource-poor schools. (p.18)

In addition to the aforementioned purpose, veteran SEEMS EMS faculty mentor, Dr. West[1] felt

> The purpose of SEEMS, to let them use their science management skills. Let them see science doing something; that if they take their management skills and what little science they know, they could actually do something for real in the world. Let them interact with a big name; realize that they can do big stuff and that they're not just a bunch of little kids. They are a part of the team, to give them the mind set that hey I can replace this dude, soon (end of program personal interview; July 24, 2007)

The curriculum for each SEEMS research group is developed primarily by a faculty member in the EMS department. EMS faculty members are given full autonomy on what their group will focus on for the duration of the program; however, most projects resemble the current research agenda of the faculty mentor. The 2007 projects focused on the climate change in Africa, forensic ice age vertebrate paleoecology, archaeological sites in Southern Egypt, molluscan body changes following the cretaceous mass extinction, petroleum engineering, polymers and material science, satellite meteorology, the basics of thermodynamics, and ozone pollution.

An in depth look at the 2007 Satellite Meteorology team was the focus of this study. This project "focuses on the use of weather satellite images to determine the height for the fair weather cumulus clouds over the Tibetan plateau" (The Pennsylvania State University Upward Bound Math & Science Center, 2007). Specifically, using polar orbiting weather satellites and Google Earth, the intended curriculum was for students to analyze cloud types and height, mapping an ideal pathway for travel in a glider from Tibet over Mount Everest. In addition to Dr. West's remark regarding the purpose of SEEMS as a whole, the intended goals for the 2007 SEEMS satellite meteorology team was a hope that the students would "gain an understanding of what can be accomplished with remote sensing of the Earth and the tools of math, statistics, and inductive reasoning, discover the links of cause and effect between terrain, weather, and time of day, and

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[1] Pseudonym used to refer to EMS faculty mentor.

explore the meteorological reasons for these relationships" (Young, 2007). Table **5-2** provides a summary of the intended outcomes categorically separating the overall outcomes associated with SEEMS from those outcomes specific to the Satellite Meteorology group.

Table **5-2**: Summary of Intended Outcomes
Summer Experience in Earth & Mineral Science
Provide opportunities to students from resource poor schools so that may experience science in a manner that will help them transition into post secondary careers in the discipline
Strengthen problem solving, observational, critical thinking, and communication skills
Allow students to use their science management skills.
Connect knowing and doing science with real-world experiences.
Connect students with scientists on an institutional level.
Build confidence and assure participants that they too can do and succeed in a science field.
Satellite Meteorology Group
Gain an understanding of what can be accomplished with remote sensing of the Earth and the tools of math, statistics, and inductive reasoning
Discover the links of cause and effect between terrain, weather, and time of day, and explore the meteorological reasons for these relationships

Dr. West's curriculum design illustrated his approach to the intended outcomes of the Satellite meteorology group in a weekly timeline (see Appendix L). This timeline provides a detailed look at the proposed week-by week objective along with the students' research task illustrating how to meet the intended goals within the research group. Table **5-3** is an abbreviation of that timeline (Appendix L) that provides a weekly summary of the intended activities.

Table 5-3: Satellite Meteorology Intended Weekly Activities

Week	Dates	Summary of Intended Weekly Activities
Week One	6/19 & 6/21	**Introduction** Hands-on introduction to MODIS weather satellite imagery. Examine typical MODIS images of weather, exploring cloud types and landscapes. Look for similarity in patterns between images. Learn to distinguish clouds from snow.
Week Two	6/26 & 6/28	**Exploring Google Earth** Learn to use Google Earth to obtain terrain height, latitude and longitude. Apply photogrammetric image analysis and inductive reasoning to understand the role of topography in cumulus cloud formation.
Week Three	7/3 & 7/5	**Using Photogrammetry** Learn to use cloud shadow photogrammetry to determine cloud height from satellite images. Calculate the cloud height as a function of location, terrain, and cloud size.
Week Four	7/10 & 7/12	**Using EXCEL™ to Analyze Data** Finish calculating the cloud height as a function of location, terrain, and cloud size. Determine the statistical relationships between cloud characteristics and terrain.
Week Five	7/17 & 7/19	**Preparing PowerPoint™** Finish determining the relationships between terrain and cloud formation. Use deductive reasoning to determine why clouds form when and where they do.
Week Six	7/24	**Practicing for the Presentation** Catch up if need be and then plan, prepare, and polish the presentation.

To what extent does SEEMS enacted curriculum align with the intended outcomes of the program?

Recall that participant interactions in the Satellite Meteorology group were audio and visually recorded. Field notes were also collected of the students' daily interactions within the group setting. A combination of field notes and audio-visual data were cross-referenced to create a more accurate record of the group's daily occurrences that represents the enacted curriculum. These enacted occurrences were coded in ten-minute increments noting different pedagogical and scientific practices. Table **4-4** identifies and defines the codes used and categorizes them according to practice.

The subsequent subsections will show the extent which the enacted curriculum is aligned with the intended outcomes of the SEEMS program and the Satellite Meteorology group. Vignettes are used to identify patterns described in the enacted curriculum. Using the coding scheme from Table **4-4**, codes documenting specific practices have been included in italics, bold, and parenthesis within the vignettes of the enacted curriculum. This was done to highlight those instances in the enacted curriculum where the mentors and research participants and are engaged in pedagogical or scientific practices.

Enacted verses Intended Curriculum for Students Enrolled in SEEMS from Resource Poor Schools: Comparing SEEMS with Participants' School Experiences

One of the major objectives of the SEEMS program is to provide opportunities for students from resource poor schools to experience science in a way that will introduce them to relevant research topics using technology and innovation (see table **5-2**, line 1). Participants enrolled in the UBMS: SEEMS program at Penn State, as previously mentioned, are from area schools in Pennsylvania and Alabama. Many of these students are low income, minorities who are first generation college students. The program provides exposure to a research experience that allows participants to interact with science in an authentic research setting, which is often quite different from their current high school science classes. To address whether the intended outcomes related to providing program participants from resource poor schools with transitional opportunities that might enhance their science experiences so that they will be able to matriculate in a science discipline in college, I have highlighted how the students compare their SEEMS experience to their high school science courses. Calvin, Althea, Sharon, and Yvette were the four students in the SEEMS Satellite Meteorology group. They all indicated that their high school science experience differed from their SEEMS research experience. Accounts from their interview illustrate their view.

Calvin is an eighteen-year-old student from Reading, Pennsylvania; he was new to the UBMS: SEEMS program. When asked about his high school science experiences he stated, "In during the classes it's just like we get papers we should study whatever and we look at books. Unlike the SEEMS we got involved with the whole situation (end of program personal interview. July 26, 2007)." Calvin's statement expressed how, compared to his high school science experience, he felt more involved in his SEEMS project. His remark illustrates the differences in how science is taught in school compared to the SEEMS program. In a follow up question, he went on to say that his experience in SEEMS was, "totally different" when compared to his high school science courses.

Althea is another student from Reading, Pennsylvania. She is a rising junior and a second year UBMS: SEEMS student. What she recounts of her high school science class experience is, "Pretty much boring most of the times." Her definition of boring when describing her high school science class meant that they, "copy notes" and "sometimes we did labs." She further explains that, "The labs were fun in umm biology because we got to dissect a crayfish and we got to dissect a frog, but everything else was pretty much boring we just copied notes most of the time and did worksheets and worked out the textbook (end of program personal interview. July 26, 2007)." Althea's remarks are self-explanatory, in that she expressed a lack of interest in the way science is taught at her high school. She further explained that science taught in this manner was not appealing to her. Whereas, other portions of her interview revealed that she enjoyed her SEEMS experience. In sharing her sentiments regarding her involvement in this project she mentioned, "…it made me more interested in meteorology (end of program personal interview. July 26, 2007)." Althea's remarks showed that she preferred hands on approach to science learning, something that she found in Dr. West's involvement of the students in their SEEMS research experience and in her high school science experience when she was able to dissect insects and animals.

Sharon is a first year SEEMS student from Reading, Pennsylvania, who was introduced to UBMS through a talent search group. In an interview, she compares her high school science experience with her SEEMS experience. She expressed,

> In biology we um studied cells and dissected insects and fish. And in chemistry, we like studied the periodic table and did lab experience. We did experiments sometimes. They were cool, like we used chemicals different types of chemical to put together and umm watched the chemicals react and form solutions. We watched the reaction and we had to copy it down like, like write our results and everything like that. In SEEMS, basically we just, we didn't do no experiences kind of. We mainly stayed at the computer for a couple of hours and research using Google Earth and Aqua and Terra and copied and like got data from the computer and pictures and basically like that. (end of program personal interview; July 26, 2007)

Sharon was the only participant who explicitly did not associate her SEEMS experience in the Satellite Meteorology group with doing an experiment. Her accounts of what occurred in the research group, helped to illustrate how the enacted curriculum provided her with an opportunity to experience science in a manner that was closely associated with those practices of researchers within this specific discipline.

Yvette is second year UBMS: SEEMS participant from Harrisburg, Pennsylvania. She is the only student who had previously worked with the current EMS faculty mentor on a SEEMS project. When asked about her high school science classes she provided remarks comparing her previous high school science class to her experience in SEEMS. She expressed,

> We would just do book work like definitions and stuff like. They wouldn't really teach us. Like well compared to here like it's more like. I don't know how to say it. I want to say hands on like but more one on one. Like experience with like professors like more one on one. Like, if you have any questions or you're lost like if you have problems like explaining it to you and then in school like we mostly do like a bunch of bookwork and reading … Like it's different. It's not the same though I just know that. (end of program personal interview. July 26, 2007)

Yvette's interpretation of her high school science experience illustrates traditional views of teaching and learning science where students are engaged in experiences that fosters learning through busy work and the memorize of facts/definitions. Her interpretation of her SEEMS science experience vastly contrast her high school experiences. She mentioned SEEMS being more hands on and, having smaller student to teacher ratio, which helped with being able to ask questions. In the end, her comments show that compared to her high school science experience, SEEMS is different in that students are more involved in the project and not subjected to just bookwork.

Three of the four participants seemed to show interest in science based on their experiences in the SEEMS program. However, Sharon expressed having more interest/ fun in her high school Chemistry classes. Although not all of the students expressed an interest in the way science learning was presented in the Satellite Meteorology group, this information showed differences in how the students view their in-school and SEEMS science learning experiences.

Dr. West, was also asked if he thought there were any differences between what he does in his SEEMS group and how the program participants experience science in their high school settings. In his response he explains,

> The science they're doing is probably only high school level because they don't know any more to get beyond that. I've been able to tailor my projects towards high school level science [so that they] are able to work on the cutting edge …So, if you pick the right project you can use high school science to do good work. So I don't think the science itself is all that far advanced to them, but the scope of the project is way bigger than you'd see in a high school science lab. They've never done anything that ran on for weeks and one task builds on the next task…(end of program personal interview. July 24, 2007)

Overall, introducing students to science in ways that expose them to the cultural practices and the nature of scientific research provided an opportunity for them to experience science outside of the traditional textbook and worksheet approach. Thus, they were exposed to science at a level beyond the traditional school science experience.

Enacted verses Intended Curriculum: Strengthening Skills and Use of Science Management Skills

In this subsection, I have grouped the SEEMS intended outcomes that emphasize the programs objective to strengthen the participants' problem solving, observational, critical thinking, and communication skills. These objectives have been combined because categorically they can all be classified as part of the participants' science management skills, as defined by the program.

Participants in the Satellite Meteorology group moved through a series of events that introduced them to remote sensing and provided opportunities to work with satellite imagery in the EMS weather lab. Instances observed from their daily interactions revealed students engaging in various scientific practices. While some of their involvement was restricted by their lack of content knowledge or the involvement of the faculty mentor/graduate student, opportunities for them to use their science knowledge while reinforcing and building their problem solving, observational, critical thinking, and communication skills were evident in both field notes and observations.

Throughout the introductory stages and the analysis portion of the experience, participation from the students was minimal. Dr. West took a didactic approach in presenting content knowledge relative to the project. However, the students did participate by generating questions to clarify points related to the project. In the following excerpt, I provide an example of students participating in the research group, asking clarifying questions. Codes from Table 4-4 were inserted in italics and bold text to mark relevant segments.

> **Calvin:** How heavy is that aircraft thingy? ***(Making sense of the problem)***
>
> **Dr. West:** The plane that he's flying is somewhere between five hundred and a thousand pounds. Depend upon which model he's in. So, let's see if you had a little four-cylinder car. That's about two thousand pounds. A light pick-up truck that's about three thousand pounds. A good high performance open class glider would be about a thousand pounds. So figure it's about a third of the weight of a small pick up truck. ***(Responding to questions, Providing background information, Providing explanations)***
>
> **Calvin:** Plus his weight? ***(Making sense of the problem)***
>
> **Dr. West:** Plus his weight. So, it's not really heavy, but the wingspan will be fifty to seventy-five feet. So, if you put his glider in this room, the width of the body would go most of the width of this room. One wing would go from the chalkboard to here. The other wing would be sticking out the far side of the building over there. Very wide, very narrow wings we'll see a picture of that. Umm K! ***(Responding to questions, Providing background information)***
>
> **Yvette:** And what is he, and what is he trying to find again? ***(Making sense of the problem)***
>
> **Dr. West:** What?
>
> **Yvette:** What is he trying to find? ***(Making sense of the problem)***
>
> **Dr. West:** He's just trying to get famous. He wants to be the first person to go over Mount Everest, and we want to tell him how high the clouds are. Over the different types of terrains: the basins and the mountains around Everest. So we need to get him the ability to look at a map and say alright, this is about what the clouds will be like on an average day this and from that he can plan what sort of route he gets in. Is he going to take hot air rising up off the mountains and climb in that or is he going to look at wind hitting the side of the mountain blowing up well what means is he going to use to gain altitude. He wants and updraft, then he needs an updraft going about thirty thousand feet above sea level cause the mountain goes to twenty nine and he has to go over the top. So, we're out there looking for clouds that we know mean updraft and seeing how high they are, and

> trying to find him an updraft to thirty thousand feet. All right? ***(Responding to questions, Providing background information)*** (Day One, Field Notes, 00:10-00:20)

Calvin asked a question that helped the group visualize the aircraft, while Yvette asked for clarification regarding the purpose of the overall research effort.

> **Althea:** So, are the clouds a good thing or bad thing for him? ***(Making sense of the problem)***
>
> **Dr. West:** Both! Isn't everything in life that way? He wants the updrafts that are heating the clouds to carry him up, but he can't fly blind through the cloud without risk of hitting the mountain. So, he wants the clouds but he wants them to be higher than the mountain is so he can get up under them and then cross over the mountain. Also the clouds, they could have updrafts, but no clouds at all. But then he doesn't know where the updrafts are so he'd love the little clouds. Cause oh I'd go to this one, this one, this one it's like having a cheat sheet on an exam if you know what all the answers are you can do anything. In his case, he wants to know where all the updrafts are and it's like okay I see a little cloud. There's one over there off I go Ah there's another one fly over there off I go. ***(Responding to questions, Providing background information)*** Alright, lets go through here. Let's look at what cumulus clouds are, and we want this picture here. You can go and read this it all should be more or less understandable. So, when you get time free to go back and browse the website go through this background material some of it's going to be really right level ***(Reinforcing and Preparing).*** Like this one and some of it gets deeper than we need it pretty fast. I'll point out the stuff you saw like that was cute and walk on. So, what we have here is height, and they're showing height in kilometers and they're showing the cumulus cloud about a kilometer off the ground. What you find Philly, nice humid place, but in Tibet I bet we're going to seem them four to six kilometers off the ground much, much higher. And this axis is showing time of day with sunrise, noon, sunset and midnight back in there. And let's think about how we want to start this. You know that you go outside right now it blazing hot out there, right? ***(Providing background information)***
> (Day One, Field Notes, 00:10-00:20)

In this excerpt, Althea asked a question about clouds and their significance to the task. This excerpt reiterates the involvement of the students showing a simple conversation where the students were communicating with the mentor by generating questions for clarification.

As the students became familiar with the tasks, instruments, and inscriptions, their involvement increased to some extent. They engaged in discussions and sometimes debates about their assertions when identifying types of clouds (Day Four, Field Notes, 01:00-01:30), distinguishing between cloud and snow, and/or describing their observations. Student participation gradually increased in the weeks following their introduction to the research project. Their participation gradually moved towards using satellite imagery to identify cloud types over different terrain and applying the use of cultural expressions relative to Satellite Meteorology to communicate their observations (Day Five, Field Notes, 00:35-2:00). These instances are records of participants using their science management skills to observe and collect data. Dr. West and the graduate student mentor helped to facilitate this process by introducing the students to multiple methods of recognizing and distinguishing cloud types and terrain using visual representations and analogous descriptions. Their involvement within the research group during the introductory period remained constant, often to the point where students were being directed where to go to find clouds and what data to record.

> **Dr. West**: Alright so let's get a new picture. So we go back in there, yep and grab the first blue one (***Introducing instruments***). Ok start orienting yourself with that basin. That's the basin right? Same tan and it's full of sand dunes – so that's the Tarin basin. Scroll around over it and see what it looks like. So you have a few cumulus up there in the north right with some congestous, right? The biggest one you are circling there is almost but not quite a thunderstorm ***(Collecting data)***.
>
> **Sharon**: This one?
>
> **Dr. West:** Yes. It's going to be there in like ten minutes. It's going to be a thunderstorm in like 10 minutes after this picture was taken. It's not spewing out any cirrus anvil yet, but it's still big. See the lumps, lumps, lumps, lumps on it? ***(Providing explanations)*** So it's probably sticking up 10 miles above the ground. Let's cruise out and see what we've got – more cirrus.
>
> **Sharon:** What's this? ***(Making sense of the problem)***
>
> **Dr. West:** That's a lake, green, probably a lot of algae in it. ***(Providing explanations)*** Let's click on the picture and get out for a second (***Introducing instruments***). There's your basin. So you have a few of those cumulus and thunderstorms and stuff but not much right? So why don't you just copy that paste it down and put scattered in front of it ***(Collecting data)***. Click twice and it will let you in. Yeah, then let's grab the file name before we forget that. Then you are off to Tibet, which pretty much everything else you've got down here is Tibet. The rest is pushing on up into Russia. So cruise around Tibet (***Introducing instruments***). I think one of the things we have to worry about

here is we're early enough in the year that we may still have some snow on the ground. Yeah you are up north of the basin. Now you are off the left hand side of your spreadsheet as it were zero. So, and there's snow up north of the basin. Cruise south of the basin. It's snow free, right? Just sand. Now we are going up the hills and we are into Tibet now – what's that stuff? That, and that? This one is probably pretty easy. You can see all the little creek channels and stuff in it. See it has fingers going into it - wrinkles. I am trying to come up with the right word and there isn't any in English. So all the little wrinkles in the ground covered with snow. So I think there's snow on the higher ground. You can see the creeks through there and there. We're in between the creeks so we must be higher. So it's like a light spring snow up high and this stuff sort of looks the same as if we have gotten some snow but then we've got these other cells in there too which might be like stratocu. Cruise south all the way to the border and see what we get **(*Introducing instruments*)**. Yeah, so we have a lot of stratocu right? The big areas of cumulus all mashed together – none of it looking all tall and lumpy, none of it casting any big shadows. Yeah now you're into snow here. That really looks like snow fading right out into stratocumulus. It is really obnoxious that you've got clouds and snow in the same place trying to tell them apart and then you've got some cirrus right down in there so you are into Tibet and you've got to deal with it. Although it is fairly uniform right? It's just smeared out all over. So you go uniform stratocumulus and cirrus ***(Collecting data)***.

Sharon: Is that one word or two words?

Dr. West: One word actually. I tend to not worry too much about minor punctuation when I am just making notes for myself. If someone famous is going to look at it I worry a bit more.

Sharon: Stratocumulus, cirrus, and what?

Dr. West: I think that's about it – cirrus what is cirrus – C I R U S right? Yeah, I think that's it. Ok, and hit return and hit the little save button. Alright, load us a new picture. Alright so where are we ***(Reinforcing and Preparing, Using instruments)***?

Sharon: I think we are in India.
(Day 4, Field Notes, 00:30-00:40)

In this excerpt, Calvin and Sharon were in a group working with Dr. West. While Calvin has no speaking part in this vignette, Sharon was working with Dr. West who was guiding her use of Google Earth and dictating notes/data. Sharon's involvement showed the lack of autonomy within the research group, thus demonstrating how guided her participation was. Dr. West walked her through selecting a site to collect cloud data. However, to some degree, his involvement was helpful to the student. As emphasized in the excerpt, Dr. West's ability to respond to questions by providing explanations when needed helped to clear up ambiguity the student had regarding the image viewed. Arguably, even though the faculty mentor was shown to be heavily involved in guiding the use of the tool/instrument, an opportunity still existed to strengthen science management skills using the instrument to observe and record of data.

The enacted curriculum had very few cases where students were engaged in the research unaccompanied by one of the Satellite Meteorology mentors. Occurrences where the students worked on their own commonly followed an instructional or demonstration piece where they were shown what information was needed and how to obtain it. Undeniably, their participation within the research group was limited because the students had very little background knowledge of satellite meteorology and for some of them this marked their first look at research in an authentic setting. The following excerpt shows students using inscriptions and engaging in science practices of using scientific instruments to collect and record data. At this point, the students were more involved in the data collection process.

Sharon: Alright I got it – 28

Yvette: shadow?

Sharon: Yea, 28, 43 – and 90, 31 and shadow elevation 15720 – ok.

Yvette: Where did you get 39? (*Sharon points to spreadsheet to show Yvette)*

Sharon (directed to Dr. West): For the solar event angle, it says dark. ***(Making sense of the problem)***

Dr. West: If it says dark that means you are on the wrong side of the planet which usually means you forgot a minus sign on longitude. (***Responding to questions)***

Sharon: *(directed to Yvette)* – alright – 58.94.

Yvette: We need cloud diameter.

Sharon: Professor, would you say this cloud diameter is around 12? ***(Making sense of the problem)***

Dr. West: *(counting pixels on the screen)*– 11 or 12 one of the two. (***Responding to questions)***

Yvette: So, should we just count? ***(Making sense of the problem)***

Sharon: Yes! (***Responding to questions)***

Yvette: Do we have to worry about displacement distance?

Sharon: It looks like it's already there. We have to do the disturbed day?

Yvette: What does that mean disturbed? ***(Making sense of the problem)***

Sharon: I guess no. Calvin, what's it mean by disturbed day? ***(Making sense of the problem)***

Calvin: Is there a lot of clouds or is there a little bit of clouds? (***Responding to questions)***

Sharon: Around the cloud that I am focusing on?

Guy 1: I think

Sharon: It looks like there's a lot of clouds right?

Guy 1: No, that doesn't look like a lot. ***(Making assertions)***

Sharon: So no? I think we are still in southern Tibet.

Guy 1: Move all the way out and you'll find the place. Right here it says link here. That's where the cloud was.

Guy 1: Where in Tibet – south?

Yvette: Southern west.

Sharon: It's right around the first one.

Yvette: So, I'm going to put southern Tibet plateau.

Sharon: Not plateau just southern Tibet.

Sharon: Let's do this one.

Yvette: Which one?

Sharon: The one above the second one – cloud x 2425 cloud y 112 shadow x 2418 shadow y 104 and the year is 2006 the day is 91 and its 445.

Yvette: Centered?

Sharon: Yes, it's centered.

(Collecting data, Using instruments, Using inscriptions)
(Day Five, Field Notes, 00:50-01:00)

In this excerpt, students were using MODIS and Google Earth to collect cloud height and location. As they worked together within their smaller groups they appropriately used inscriptions to ask questions and to dictate the numbers that were entered into the Excel™ spreadsheet. This example also shows students collaborating with one another to define a disturbed day.

Overall, participation in the SEEMS Satellite Meteorology group provided opportunities for the participants to contribute to the research group in ways that allowed them to use basic knowledge about satellite meteorology combined with their prior knowledge and skills in the areas of mathematics, science, and technology. Components of this project required basic knowledge of maps and directional terms. Admittedly, the students in this group represented different levels of knowing. They did not have the same mathematical background or science content knowledge. However, they were able to participate in the discussion using what knowledge they had and knowledge gained from their introduction to the project. Furthermore, students were able to use their technological skills to contribute to the research group as demonstrated by their contribution to operating the imagery software, recording data using Excel™, designing figures and drawings that illustrated their findings, and pulling together a structured presentation.

Involvement in a project structured so that participants can experience the cultural practices of science to some extent provided opportunities to build upon higher order thinking and communication skills. Though very little can be said about the other 2007 SEEMS research projects, the intended curriculum for students who participated in the Satellite Meteorology group does suggest the presences of opportunities for students to enhance and develop their science research skills.

Enacted verses Intended Curriculum: Connecting Students to Research Scientists, Building Confidence, and Connecting Real-World Experiences

In this subsection, I present findings associated with the SEEMS intended outcome that emphasizes making connections to real world experiences, connecting students with scientists, and building confidence. Among barriers commonly associated with the lack of minorities in science and mathematics is the perception that these disciplines are not for them (Kahle, et al., 2000; Schiebinger, 1999; Stake & Mares, 2001). SEEMS attempts to connect research scientists in the field with students so that they can experience science from an authentic standpoint and to make the work done in EMS seem attainable.

In 2007, fifteen different research experiences were structured so that students would have a chance to work with scientists and/or graduate students on projects aligned with the interest or research agenda of an EMS faculty mentor which created opportunities for program participants to engage in scientific research in an authentic setting with researchers in their respective disciplines. As a result, some students also built long lasting relationships with other program participants and their faculty mentors. These opportunities are favorable for retaining underrepresented groups in science, in that students are able to foster relationships or social networks with their peers, possibly helping them overcome their isolation within the discipline (Barlow & Villarejo, 2004; Chatman, 2005). Exposure to programs like SEEMS allows students a chance to see how attainable a career in science is. Dr. West speaks of one of his first SEEMS students in the excerpt below.

> I'm watching one of my first SEEMS students who just got her admittance to engineering graduate school in Ohio…. Every semester she sends a bragging emails that much closer, that much closer. It's clear from the get goes, if I can do what he does yeah that's doable. I think that's where SEEMS really shines, is it makes professors, researchers, etc human. Let's you see that, that role is attainable. Hey I did it for a summer, I can do it for life. (end of program personal interview; July 24, 2007)

The nature of this statement illustrates how powerful a tool programs like SEEMS can be for students. Having positive role models and mentors can help to build confidence in those who may be unsure of there place in the realm of science. Althea, recalls from their presentation encouraging words from Dr. West regarding their presentation. She stated, "…<name of faculty mentor> said that I sound real professional when I did it so" (Althea end of program personal interview; July 26, 2007). This statement was in response to whether she felt what she had to contribute to the research project and group was important. The idea of coming across as professional and showing expertise when reporting the results of their presentation to some extent had a positive effect on how she viewed herself in the research group and possibly within the discipline.

In addition, to networking and confidence building, each SEEMS research project was structured so that program participants could see how their work within their respective research groups was connected and applied in the real world. The intended curriculum for UBMS/SEEMS as a whole is designed to introduce students to science in an authentic research setting. Appendix M provides an overview of the varying teams by title and the objectives of each project. The 2007 SEEMS research projects all showed potential in introducing students to science at a level where they could see connections between what they were doing and where it fits in the grand scheme of the real world. My involvement focused on the experience of participants in one group. Consequently, the extent to which real world connections are made via the enacted curriculum only reflects the experiences of the students in the Satellite Meteorology group.

The purpose of the Satellite Meteorology project was to help Dr. Harold[2] fly a glider plane over Mount Everest. Participants were introduced to the goal of the research project within the first week of their experience. This connection showed students a direct relationship between their research objectives and its application to the real world. Providing students with a storyline

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[2] Pseudonym used to denote the scientist/pilot who wants to fly over Everest.

or mission as the driving force behind the research projects allowed students to make a connection between the work they were doing within the research group and how Dr. Harold would benefit from it. Evidence supporting this connection was found in their responses during their interviews. When asked to explain the purpose of their project or what their project was about, each of the four students clearly articulated that they were working to help Dr. Harold in his attempt to be the first man to fly over Mount Everest in a glider plane.

Students are interested in connections between what they learn and their everyday lives (Basu & Barton, 2007; Rahm, 2002). One of the most cohesive components of this group was the opportunity to apply the things they were learning to their everyday lives or to see connections in what they were doing and how it would be applied. In addition to showing how their research objectives were going to apply to something real, students were able to see connections in what they were learning and its use in the real world. After becoming familiar with different cloud types online, the students were asked to apply what they had learned about cloud identification to clouds they viewed out of the lab window. Although they struggled with cloud identification at first, by the end of their experience they each showed growth in being able to successfully identify varying cloud types. Dr. West also allowed the students to experiment with the software where they attempted to find their homes and other familiar landmarks using the Google Earth application. This allow students a chance to see how the same imaging system they would use to find clouds could also be used to locate geographical points of interest.

Instances that enable learners to make connections between what they learn and its real world application can begin to emulate the situated nature of learning and applying science. Connecting science to real world practices helps to foster science literacy as it introduces science in a manner that may interest learners by illustrating how science relates to the world around them and/or issues that are important to them.

Enacted verses Intended Curriculum: Understanding what can be accomplished and discovering the links of cause and effect between terrain, weather, and time of day

As the students piled into the research lab they would be working in, their experience began with a brief overview of their project. Dr. West provided an introduction where he gave a general idea of what the students would be looking for in order to get Dr. Harold over Mount Everest.

> So we're going to be looking down, we've got an archive of years and years of pictures available and we can go in there once or twice a day and get a picture and say alright how high were the clouds? Now, certainly, we're not going to look at years and years, but we are going to look at as many as we can, a few dozen pictures probably and several clouds in each. End up with a pool of may be one hundred or two hundred clouds. We know where the cloud was. What the terrain under it was like. Was it over a mountain? Was it over a basin? Over the lakes? What? And try and work out how high were the clouds and how does that height relate to the height of the ground under it. Is he going to get the higher clouds over the mountains? Over the basins? Everything we can to tell him what type of clouds to expect where as he works his way in across Nepal or Tibet trying to get to Everest, and then can he make it over Everest? ***(Providing Background information)*** (Day One, Field Notes, 00:00-00:20)

This explanation introduced how the group was going to attack the research problem. Though the explanation does give much detail, the rest of the continued conversation provided more insight on how this would be accomplished using clouds.

> … We want to tell him how high the clouds are over the different types of terrains, the basins, and the mountains around Everest. So, we need to get him the ability to look at a map and say alright, this is about what the clouds will be like on an average day this and from that he can plan what sort of route he gets in. Is he going to take hot air rising up off the mountains and climb in that or is he going to look at wind hitting the side of the mountain blowing up well what means is he going to use to gain altitude? He wants and updraft, then he needs an updraft going about thirty thousand feet above sea level cause the mountain goes to twenty nine and he has to go over the top. So, we're out there looking for clouds that we know mean updraft and seeing how high they are, and trying to find him an updraft to thirty thousand feet. Alright? Meanwhile he's bribing a bunch of Tibetans to launch weather balloons for him trying to get the same information, but they can't measure how high the clouds are. They can only measure how high they think the updrafts are going. So we're going to collaborate with what the Tibetans are doing. They'll go one method, we'll go another method to get the same answer from both of us he believes. If it's different answers he's got to figure out, why the difference and go from there.

> Alright? ***(Providing Background information)*** (Day One, Field Notes, 00:00-00:20)

Based upon the dialogue regarding the approach to the research problem and the collaboration of Dr. Harold and Tibetan scientists, Dr. West used remote sensing to explain how the students would be working on a project primarily based in Asia.

> …So we're trying to go, and we're trying to get an understanding of remote sensing and so its our first goal. Remote sensing means we don't go into the lab and work with the chemicals and whatever. We sit here, the satellite sits in orbit, it looks, we look at the pictures and measure things off of the pictures. We don't have to leave our air-conditioned lab and we still get to do science. So it's sort of the cushy homebody version of science. As opposed to Ward, who's going to go over there in Nepal, pack his glider up hundreds of miles into the mountains and get somebody to tow him off? ***(Providing Background information)*** (Day One, Field Notes, 00:00-00:20)

As he continued his conversation about remote sensing, Dr. West provided an explanation on mathematics, and inductive reasoning to give students an idea of how the three components were intertwined.

> **Dr. West:** We're going to use some statistics to try and take make many observations and squeeze them down into a small number of answers, and then inductive reasoning. And inductive reasoning is fairly simple, it says I'm working from a lot of cases to a rule. Deductive reasons I have a rule. So, give you an example of deductive. If I know gravity pulls things down. And I know this is covered with chalk dust, and I hold it over her head and let go, are you going to be covered with chalk dust or not? ***(Providing Background information)***
>
> **Althea:** Yeah!
>
> **Dr. West:** Okay, that's deductive reasoning. Right? Now if I drop this on your head? And her head, and hers and his? And you all get chalk dust on your head. You could induce the rule without understanding the physics. All right? It's like wait a minute we all got hit with chalk dust. I bet there's chalk dust on that thing. Umm? So, if you have lots of cases and you learn from experience that's inductive reasoning. If they pounded the rules into you in school and you put them together, that's deductive. So, we've got lots of pictures and we only have a shaky understanding of the science. We're supposed to discover the science, so we're using inductive reasoning. A lot of what you learning in school is science somebody already learned and so you can use deductive, but when you are on the frontier like we are you don't know all the rules. You've got to discover the rules and the only way to discover the rules is to just look at a lot of cases and say you know that happens most of the time. I bet that's a rule, and so that's the

> inductive bit… So, we're going to discover the links of cause and effects between terrains, that is the mountains, the basins, and the weather and the time of day. So, given a bunch of lumpy terrains with mountains, basins, lakes, how does the weather evolve? There's some general theory that we'll see today that we're going to make sure that's really working there in Tibet and not something else crazy happening. We may be blind sighted by stuff we didn't expect that happens a lot in science. So, we're going to probably going to verify some things that people thought they knew. You find out that some of them don't quite work that way where Ward is going. Okay, and then were going try and, after we know what the pattern is try and figure out why that would be true. ***(Providing Background information)*** (Day One, Field Notes, 00:00-00:20)

The synopsis provided on the first day of the research experience lays the foundation for the students regarding how they were going to approach to the research problem using remote sensing, math, and inductive reasoning. This overview summarizes and provides an explanation of what can be accomplished using these tools, however it does not measure whether the students completely understood how the approach would contribute to finding a solution to the proposed research problem. Students' daily participation using MODIS and Google Earth provided an opportunity to work with remote sensing to collect data on various cloud types and location over differing terrain. This was a better measure of how the students began to understand the relationship between the variables.

> **Dr. West:** So we've got cirrus and in the middle there are a bunch of thunderstorms you can just see the lumpy tops here and then a lot there so we've got a line of thunderstorms here with debris flying that way so its probably not something Ward would want to fly through because it is probably full of lightening and hail. Then down here you've got some smaller thunderstorms; you see the little cumulus with their shadows? So we are getting some days with the cumulus up over the mountain tops – in the foothills and even here in the high mountains and some places there we've got snow up above but a lot of places we've got cumulus clouds up there casting shadows on snow and then in there a little bit of cumulus clouds right across the snow; the snow looks angular like it was built out of broken glass and the cumulus looks like it was built out of cotton balls or peas. So once you get the artistic difference down between the two you can start separating. It's a lot easier for a good human to tell the difference than computers – computers have a hard time telling them apart. ***(Providing Background information)*** (Dr. West asks Girls 2 and 3) – Would you say this is a disturbed day or a undisturbed day? ***(Reinforcing and Preparing)***
>
> **Girls:** Disturbed day.

> **Dr. West:** Right, there's the high mountain crest and you've got a tiny little cumulus right along the crest but here there ringing the valleys right at the edge of the snow line and they are less disturbed in this part – fewer clouds – but we're going to have to zoom out to see where we are. We certainly have a lot of really big valleys in there. There's the terrain basin. There's Tibet, so this is northern Pakistan, India is there, and Everest is down somewhere. There's the …. towards Afghanistan – so way up Northwest of there were disturbed down here and undisturbed up there. In disturbed you had clouds everywhere particularly over the mountain tops and in undisturbed they formed a little rim as high as they could get without going over snow. So they are trying to get high but when they see that snow they say ok this stuff is cold it won't go up so they stop. Ok keep looking, you want to look at enough cases to make sure the pattern holds up that it is not just our imagination, and once you are convinced of it, we will open up Word and write about what we are seeing. What do we see on disturbed days and what do we see on undisturbed days. ***(Providing Background information*** (Day 8, Field Notes, 1:20:00-1:30:00)

In the sessions prior to the one used above, students collected data on clouds. The students recorded, in Excel™, the cloud location, shadow longitude and latitude, noted the terrain the cloud was over, time of day, and date. Trigonometric formulas were preset in Excel™ to calculate and compute the varying heights of the clouds. The excerpt features Sharon and Althea asking Dr. West for help working on the cloud review that followed the following the statistical analysis of the quantitative data. Through their observations and with some help from the group mentors, the students saw how remote sensing, mathematics, could be used to make assertions about the data.

The Nature of the Students' Engagement in the SEEMS Research

Table 5-4: The Nature of the Students' Engagement in the SEEMS Research

In what ways do students make sense of and apply science concepts as they engage in the research (e.g., understand problem, how they interpret data, how the construct explanations), and the extent to which they use the science content appropriately?
In what ways do students engage in the cultural practices of science, such as using scientific discourse, interpreting inscriptions, and constructing explanations from evidence? (engaging in science practices, knowing science and doing science)

In what ways do students make sense of and apply science concepts as they engage in the research (e.g., understand problem, how they interpret data, how they construct explanations), and the extent to which they use the science content appropriately?

The research questions that focused on the nature of the SEEMS research experience used students' involvement in scientific practices to determine whether the intended and enacted curriculum were aligned. This approach provides some insight into how students engaged in science, but it does not adequately assess students' understanding of the science research they engaged in. Consequentially, I analyzed students' preparation for their final presentation, the enacted presentation, and interview, as sources to gauge the students' understanding of the research objectives, concepts, and the extent to which the students were able to interpret data and construct explanations. Students began working on the final presentation on day eight, following the data collection and statistical analysis, and continued to day eleven. Analysis of field notes and transcripts showed students involvement in preparing for the presentation. In the subsequent paragraphs I outline a few daily occurrences that highlight oral and visual representations that illustrate how the students the made sense of, applied, and used concepts as they engage in the research.

An event map (table **5-5**) illustrates the major episodes of day eight in ten-minute increments. In addition to working with Excel™ to calculate and analyze the data, participants also created an illustration (figure **5-1**) showing where the clouds are relative to the mountain on a disturbed day compared to an undisturbed day (Day 8, Field Notes, 1:30-1:40) to help explain their results. Disturbed and undisturbed days refer to the abundance of clouds in the sky. Disturbed days represent days where a number of clouds are present, and undisturbed days represent days where fewer clouds exist.

Table 5-5: Event Map Day Eight

Date/Day	Time	Main Event	Comment
7/12/2007 Day 8	00:00-00:10	Summarizing the previous week	
	00:10-00:20	Working in Excel[a] (Formula setting)	One student working others are engaged in other conversations
	00:20-00:30	Plugging in equations in Excel[a]	
	00:30-00:40	Plugging in equations in Excel[a]	
	00:40-00:50	Plugging data into Excel[a]	Punching in numbers
	00:50-1:00	Reviewing data in Excel[a]	
	1:00-1:10	Reviewing data in Excel[a]	
	1:10-1:20	Designing illustration/figures	Graduate Student mentor working with a small group of students on design
	1:20-1:30	Interpreting the data	
	1:30- 1:40	Interpreting the data Preparing notes for the presentation	
	1:40-1:50	Reviewing patterns within the data	
	1:50-2:00	Developing illustration/figure	
	2:10-2:20	Summarizing the day and upcoming objectives	

The graduate student mentor heavily assisted this group with the representation of their use of trigonometry. Using Microsoft paint™, Figure 5-1 was designed by the students and the graduate student mentor. The diagram illustrates the cloud height above ground level (Hagl), diameter of the cloud (Dcloud), height of the cloud above mean sea level (Hmsl), shadow displacement (Sdisp), and height of the shadow above sea level (Hshadow). It shows how trigonometry was used to get the shadow elevation so that Dr. Harold would be able to know the location of clouds relative to the mountain on a disturbed day compared to an undisturbed day.

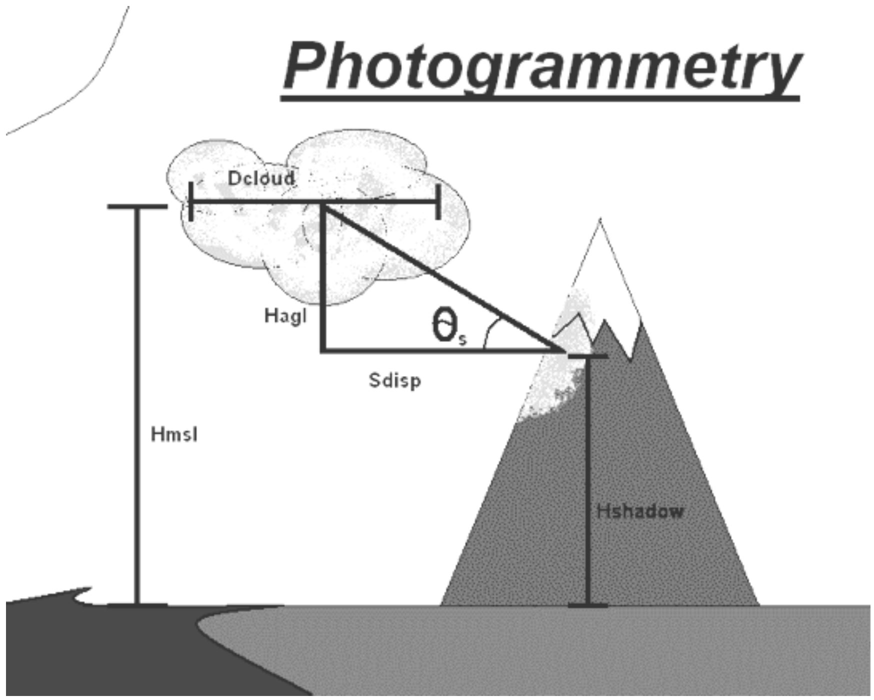

Figure 5-1: Cloud Height: Photogrammetry.

The exchange between the students and graduate mentor when Figure 5-1 was developed showed students posing questions, trying to make sense of the figure. Other exchanges that occurred showed both mentors conferring with one another about the accuracy of the drawing. Better insight into students' understanding of this representation was revealed in the analysis of day eleven; as a result, I provide the following excerpt in this section (events from day eight).

Calvin: What's the S disp again? The disp? ***(Making sense of the problem)***

Dr. West: Shadow displacement. ***(Responding to questions)***

Calvin: All right.

Dr. West: Just shadow length. I think I used too fancy a word when I said it the first time. I should have used length instead of displacement. All right. And H shadow is what? ***(Responding to questions)***

Calvin: Height from the ground. (***Constructing explanations)***

Dr. West: Okay.

Calvin: Oh, H shadow? How high of a shadow above sea level. ***(Using inscriptions)***

Dr. West: Above sea level. So it's terrain height basically right? ***(Reinforcing and Preparing)***

Calvin: Above sea level or ground level? ***(Making sense of the problem)***

Dr. West: Well ground level . . . it better have height of 0 above ground level right? ***(Responding to questions)***

Graduate Student: Your shadow is longer. ***(Providing background information)***

Dr. West: Yeah shadows are on the ground. So H shadow better be h of ground, which has got to be 0 above ground for a definition. Ground sits on ground. So it's got to be height of the ground above sea level. And diameter of the cloud. Okay… ***(Responding to questions)***
(Day 11, Field Notes, 00:50-1:00)

Calvin worked with the graduate student mentor to develop Figure **5-1**. This excerpt shows Calvin's lack of understanding about the diagram. Notice that his initial question focused on what "disp" represented in the figure. The second point is Calvin's response to what Hshadow is. Calvin mentioned that Hshadow represents the shadow height above sea level. Calvin's use of *high* semantically leads Dr. West and the graduate mentor to believe that the misunderstanding Calvin has of Hshadow was that the shadow of the cloud had height off of the ground. Dr. West tried to get Calvin to see that Hshadow is the shadow location with respect to its location above the ground. Thus, Dr. West's explanation that the height of any shadow is zero, and a better way to state what Hshadow represents was to say that Hshadow represented the height of the ground above sea level. This meant that the shadow was located on mountainous terrain, which has height, and the location of the shadow was at a height represented by Hshadow. This excerpt shows the complexity of discourse within science communities, and to some extent that opportunities to participate in science research does not guarantee acculturation into discourse in the science community: Calvin's use of *high* to explain Hshadow was semantically incorrect.

Arguably, what he expressed, “how high of a shadow above sea level,” represented the location of the shadow cast with respect to the mountain.

An event map of day nine (Table 5-6) illustrates students primarily engaged in analyzing data in Excel™ and preparing for their presentation. Analysis of the video from day nine opens with Dr. West working with Yvette creating notes for the presentation while the other students (Calvin, Sharon, and Althea) outlined the presentation with the graduate student mentor. Dr. West’s approach with Yvette was instructive, in that he walked her through the strategy for getting Dr. Harold over Mount Everest. Instances in the transcript showed Dr. West leading the conversation, dictating instructions, and lecturing. The following excerpt is one of two over a period of one hour that illustrated Yvette’s basic understanding of the flight strategy.

> **Dr. West:** What’s bad about the disturbed days? ***(Reinforcing and Preparing)***
>
> **Yvette:** There is more clouds. ***(Constructing Explanations)***
>
> **Dr. West:** Yeah there is the big cirrus blankets over the mountain. We’re saying the cirrus blankets might obscure Everest on certain days.
> (Day 9, Field Notes, 00:30-00:40)

Note that in the excerpt the student is able to communicate the type of day needed to successfully fly the glider plane over Everest. This shows a basic understanding of the risk associated with flying the glider plane on a disturbed day and to some extent her understanding of the data and how she was able to construct an explanation.

The next excerpt illustrates Yvette’s understanding of the content through a summary of the information provided on cloud height. In this example, Dr. West is reading aloud Yvette’s summary.

> **Dr. West:** Okay. So, you said that *(reading Yvette’s entry on the computer)* “lower clouds are more affected by wind.” And I showed that wind clouds mixing. So, you could say lower clouds are more easily evaporated by wind mixing or something like that. ***(Making assertions)***
> (Day 9, Field Notes, 00:40-00:50)

Table 5-6: Event Map Day Nine.

Date/Day	Time	Main Event	Comment
	00:00-00:10	Summary of the daily objectives	
	00:10-00:20	Collecting data in group	Student inputting information as it is being dictated by Dr. West
	00:20-00:30	Plugging data into Excel[a]	Student inputting information as it is being dictated by Dr. West
	00:30-00:40	Discussion of the flight plan and results	Dr. West leads. Students listening very little dialogue
	00:40-00:50	Discussion of the flight plans and results	
	00:50-1:00	Discussing cloud height Organizing the PowerPoint[a] presentation	
	1:00-1:10	Making sense of AGL	
	1:10-1:20	Outlining the presentation	
	1:20-1:30	Organizing the presentation	
	1:30- 1:40	Finding picture for background of slide	
	1:40-1:50	Surfing using Google Earth	Students off task for most of this section
	1:50-2:00	Discussing personal lives	Students off task for most of this section
	2:10-2:20	Surfing using Google Earth	Irrelevant to the presentation/ research question

Her understanding of the concept of lower clouds being affected by wind was her way of expressing that the lower clouds would evaporate as a result of the wind mixing with the dry air. Although her statement does not give full detail of what the wind does to the cloud. Here again, she illustrates an understanding that the wind affects lower clouds to some degree.

While Dr. West and Yvette were working together, the other group members (Calvin, Sharon, and Althea) and the graduate mentor began preparing basic slides for the presentation. Both groups were fairly close together which made it difficult to hear both discussions. However, when the groups joined, the discussion focused on designing a background for slide show, finding illustrations, and the logistics and organization of the slide order. The dialogue between the students and the researcher on this day was limited, however, an episode of significance that surfaced was a dialogue between Calvin, Althea, and the graduate student mentor.

Althea: Go to that picture again. Go to the picture.

Calvin: The one of Mount Everest?

Althea: Look at the . . . ain't that cirrus? (***Making sense of the problem)***

Calvin: Look at the stars. That's so beautiful. This? *(pointing at the screen)*

Althea: Yeah.

Grad Student: That's awfully thick to be cirrus. (***Responding to questions)***

Calvin: Isn't . . . that's a perfect cloud. Like I'm up and over. Looks like I'm right over it.

Grad Student: They don't have a very strong updraft. (***Responding to questions)***

Althea: Is this supposed to be clouds down there? (***Making sense of the problem)***

Calvin: Um, hm. (***Responding to questions)***

Althea: All the way down there? (***Making sense of the problem)***

Calvin: Um, hm. There's clouds there, right there, right there. All murderous clouds. (***Responding to questions)***

Althea: Murderous? (***Making sense of the problem)***

Calvin: Yeah cause if you was to try to fly up it would make you crash. (***Responding to questions, Constructing explanations)***

(Using instruments, Using inscriptions)
(Day 9, Field Notes, 1:40-1:50)

In this excerpt, the students were engaging in a dialogue while using Google Earth. Althea questioned the image on the computer screen. In the first part of the excerpt she questioned the cloud type, whereas, in the second she questioned what she was viewing relative to the location. What is important in this vignette is Calvin's response to Althea's second question. His use of the term "murderous" to identify clouds that contained a strong updraft that would cause the glider plane to rise too fast and possibly cause an accident was a good example of how he was able to make sense of the research.

The intended objective for day ten was to have the students create PowerPoint™ presentation. An event map of day ten provides details of the major occurrences in ten-minute increments. Note that at the beginning of the session student were separated in two groups, one working on the slide show with the graduate student mentor and the other engaged in designing an illustration in Photoshop™ that would represent the projected flight path over Mount Everest. Further analysis of the field notes showed the graduate student mentor at the lead, controlling the input of information into the slides and guiding the students for an extensive period of time (Day 10, Field Notes, 00:00-00:55). Dr. West expressed to his graduate student that she should allow the students to work on the slides. He stated, "<Name of Graduate Student>, let them do a few things as well as yelling instructions at them" (Day 10, Field Notes, 00:53-00:54). Later in the transcript she was reminded again by Dr. West to allow students the opportunity to work with the slides. He sated, "Shouldn't you let somebody else be doing this" (Day 10, Field Notes, 02:01-02:02). The point that Dr. West made, in both cases, was that that the graduate student mentor was heavily involved in the presentation development and had not allowed the students to work on inputting the text onto the slides. Prior to both moments, Yvette and Althea were working with the graduate student mentor as she conferred with them on what information should be apart of the slide show.

Table 5-7: Event Map Day Ten.

Date/Day	Time	Main Event	Comment
	00:00-00:10	Rewording the problem statement * Designing illustration for presentation	Adjusting the slides *Dr. West and Calvin working together
	00:10-00:20	Discussing the layout of pictures on the slides *Designing the illustration	Graduate Student mentor leading the group * Discussion of colors. Calvin works with Photoshop[a] on the design.
	20:00- 30:00	Organizing and Laying out the presentation *Perfecting the image	Discussion on what to include in the presentation. What illustrations/representations are needed *Dr. West shows Calvin how to layer pictures in Photoshop[a] .
	30:00-40:00	Discussing MODIS satellite and its operation * Using Photoshop[a]	Graduate Student mentor explains MODIS and its sun synchronous orbit *Calvin is learning to navigate Photoshop[a]
	40:00- 50:00	Reviewing the aesthetics of the presentation * Working with the image	Dr. West checks to see if the font, font size are appropriate for the slide show *Determining how to represent snow
	50:00-1:00	Working on the PowerPoint[a] slides *Finalizing the image	Althea takes over at the computer station.
	1:00-1:10	Discussing slide arrangement *Saving the image	Organizing the talk- Who's doing what?
	1:10-1:20	Discussing terminology	What is average? What is standard deviation?
	1:20-1:30	Discussing formulas used	Graduate Student mentor back in front of the computer working on the slides
	1:30- 1:40	*Both groups combine*	
	1:40-1:50	Finding the notes on the results section	Locating information that may be on another machine. Student conversation on personal lives.
	1:50-2:00	Discussing personal lives	
	2;00-2:10	Putting the finishing touches on the slides	Graduate Student mentor leading
	2:10-2:20	Discussing how to respond to questions.	Graduate Student mentor leading
	2:20-2:30	Wrapping up	Are possible errors and future research to be included?
	2:30-2:40	Assigning the slides	
	2:40-2:50	Colleting a printout	

*Indicates second group.

The excerpt below provides an example of how the graduate student was involved.

> **Althea:** I don't like this page. I ain't never seen . . . this, what we did on there?
>
> **Graduate Student:** Yeah we're, we're going to have to reword them. So if there's nothing wrong with this site . . . all right the introduction. All right so this is our problem. You wanted to reword this?
>
> **Althea:** Yeah.
>
> **Graduate Student:** Is it the fact that it's a, a question that you don't . . .
>
> **Althea:** It was boring me. I don't know. It's not boring but I don't, I don't know. It just don't seem right to me for some reason.
>
> **Graduate Student:** We could make it a couple of bullets and put it as <pilot> plans to be the first person to glide over Mt. Everest using a, like a plane without an engine.
>
> **Althea:** Yeah. That would be good.
>
> **Graduate Student:** Rather than it be a question?
>
> **Althea:** Yeah.
>
> **Graduate Student:** So let's write can glide over Mt. Everest . . . pass over the peaks of Mount Everest using only a glider plane without an engine.
>
> ***(Publishing)***
> (Day 11, Field Notes, 00:00-00:10)

Analysis of the video showed the graduate student mentor at the computer and Yvette and Althea off to the side. This excerpt shows Althea's level of engagement with the graduate student mentor. Although she was not at the computer developing the slide, she was contributing to the presentation. What I would like to highlight is how the graduate student reworded part of the introduction when she could have allowed the students to come up with the wording for the slide. This would have provided the students with an opportunity to engage in the cultural practice of constructing their own explanation.

> **Graduate Student:** …Now what do we want to do here about pictures? Do you want to find a picture of each cloud? Do you want to use the satellite picture of the cloud?
>
> **Althea**: I think we should just use the satellite picture?

Yvette: Yeah. Since we, that's what we've been looking at.

Graduate Student: So I like the picture on this side. If we can find a satellite picture do we have to have a picture of each one or just a general . . .

Althea: Try to get a picture of all of them in there. Or at least . . .

Graduate Student: Well as long as you describe the other two.

Yvette: Yeah.

Graduate Student: You can get one that has . . . well you need cumulus clouds because that's what you look at. And it could have others in that image we use. You could say and here is some . . .

Yvette: We can do that.

Graduate Student: Do you want to put cumulus last? That way it's fresh in their mind when we talk about more stuff?

Althea: Yeah.

(Publishing)
(Day 10, Field Notes, 00:20-00:30)

The excerpt above is an example of students interacting with the graduate student mentor. The dialogue between them illustrates the extent the students were involved and how the graduate student facilitated the slide development. Note how the graduate student conferred with the Althea and Yvette about what they wanted to include in the presentation. She gave advice about how they could present background information on the different types of clouds if they decided not to include them in the slide show, and suggested they include a picture of a cumulus cloud. These instances are not highlighted to reflect that the graduate student's participation within the group as negative; however, it is highlighted to illustrate the level of participation the students had in developing the slide show. Although their engagement in developing the presentation was supported through their mentors, field and video notes showed that students were actively engaged throughout this process actively participating and contributing to the research presentation.

Group two consisted of Calvin and Sharon working with Dr. West to create a figure in Photoshop™ to represent the flight plans (see figure **5-2**).

> **Dr. West**: So let's sketch it out. So we need to be able to capture that difference in angle and this difference in elevation. So there's going . . .circle a lot but we're going to draw some spirals cause what he's really doing is spiraling up like that. He's doing a circle in an updraft that's carrying him up. ***(Publishing)***
>
> **Calvin:** Wait. Where is he starting at? He's starting right there? ***(Making sense of the problem)***
>
> **Dr. West**: Right at . . . yeah cause this is the closest cloud with it's own line of cumulus right at the snow edge here and here. (***Responding to questions)***
>
> **Calvin:** So there's going to be a plane flying in through there and it's going to drop him off? ***(Making sense of the problem)***
>
> **Dr. West**: Or he can get dropped off further . . . we'll worry about how he got here later. ***(Responding to questions)***
>
> **Calvin:** Okay.
>
> **Dr. West**: Let's start at the challenging parts and then we'll work backwards to parts where we have lots of options.
>
> **Calvin:** Okay.
> (Day 10, Field Notes, 03:00-03:10)

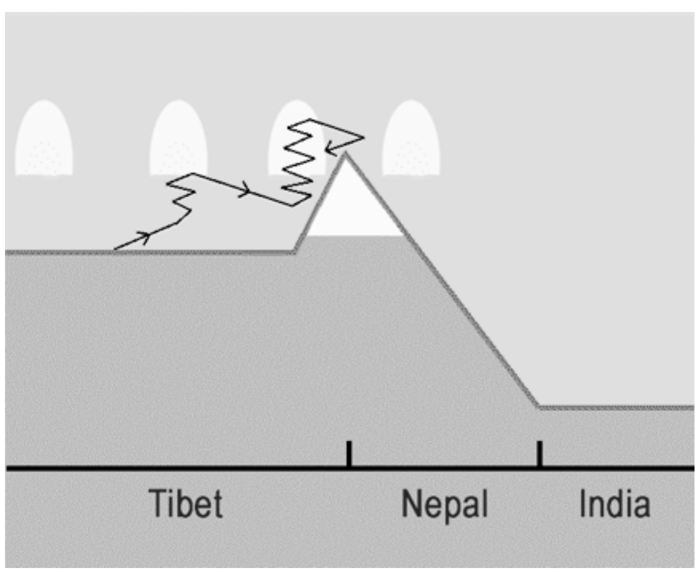

Figure **5-2**: Planned Route.

Eighty minutes of video was recorded of group two on day ten. In those eighty minutes, the transcript does not show Sharon engaged in the development of the Figure 5-2. The dialogue is was primarily between Dr. West and Calvin. The previous excerpt showed Dr. West mapping out the proposed flight plan that Calvin attempted to recreate in Photoshop™. The diagram shows the proposed flight plan suggesting that Dr. Harold begin his flight path on the North side of Mount Everest in Tibet continuing toward Nepal and India. Little can be determined from the transcript and field notes about the ways Sharon and Calvin made sense of the data, however, the illustration can be interpreted as a visual representation of their understanding (Crawford, 2005).

Day eleven was the final day before the presentation. The following event map describes major occurrences in ten-minute increments as the students prepare for their presentation. This day was used to reinforce and prepare students by asking them questions to prepare them for the presentation and allowing them to ask questions for clarity. Analysis of the transcript and field note revealed student engagement in making sense of the problem, constructing explanations and using inscriptions appropriately. Prior to the reinforcement session some of the questions the students sought information for included the use of above sea level (ASL) and above ground level (HGL), further research, the definition of tangent.

Table 5-8: Event Map Day Eleven.

Date/Day	Time	Main Event	Comment
7/24/2007 Day 11	00:00-00:10	Clarifying parts in the presentation	
	00:10-00:20	Talking about presentation attire	Talk among students
	00:20-00:30	Discussing what should be presented	Consulting with Graduate Student Mentor on presentation
	00:30-00:40	Addressing last minute inquiries	Calvin wanted to know how the plane lands
	00:40-00:50	Quizzing the students	Preparing the students for the question/answer session
	00:50-1:00	Quizzing the students	Dr. West had to address some misunderstanding of information.
	1:00-1:10	Discussing the disadvantages	Dr. West quizzes student on some of the disadvantages and solutions of flying a glider plane.
	1:10-1:20	Wrapping up	Students want to know if the work they done is going to be used? How will it get to the other researcher?

The following excerpts represent instances in the transcript where each student responding to reinforcement in preparing for the presentation. In most cases Dr. West delivered the questions while the students responded.

Excerpt 11a
Dr. West: …Why are you telling us about stratus and cirrus when you're going to be flying mostly under the cumulus clouds? ***(Reinforcing and Preparing)***

Yvette: You said why?

Dr. West: I'm asking all these questions.

Yvette: Oh. Because those are clouds you don't want around during the, at the time. ***(Constructing explanations)***

Dr. West: Know thy enemies. Very good answer…

Dr. West: Okay. Why are cumulus good and the others aren't? ***(Reinforcing and Preparing)***

Althea: Because the cumulus clouds are the clouds where we have the most, warm updrafts that will bring it up. ***(Constructing explanations, Using inscriptions)***
(Day 11, Field Notes, 00:30-00:40)

In the aforementioned excerpt, Dr. West was preparing the group for the question and answer session of the presentation. Yvette's response to why the presentation did not focus on one cloud type showed that she was able to justify why certain information was included in the slide show. The follow up question answered by Althea showed her understanding of why cumulus clouds were important. Her use of the term *warm updrafts* showed that she was able to make sense of the research and use the appropriate inscription to justify her response. The following excerpt makes some of the same connections, however, in this vignette the student is explains what an image is and how it works.

<u>Excerpt 11b</u>
Dr. West: All right. Let's see what else we got. Tell me about the picture there. I mean what's that satellite doing? ***(Reinforcing and Preparing)***

Althea: Oh well in the image you see the satellite orbiting the globe in a synchronized fashion. ***(Constructing explanations, Using inscriptions)***

Dr. West: What does synchronized mean? ***(Reinforcing and Preparing)***

Althea: Going back the same, same area. ***(Constructing explanations)***
(Day 11, Field Notes, 00:40-00:50)

Althea responded to Dr. West's question about an image the slide show. Note that in her response she is able to articulate what the image was and what it does. Her use of and ability to define the word *synchronized*, which she used to describe how the satellite orbits the globe, shows how she was able to make sense of what the image was and how it operated. The subsequent excerpt questions were still asked about images in the presentation. Calvin was asked to identify geographic locations with respect to Figure **5-2**.

<u>Excerpt 11c</u>
Dr. West: Where's Tibet in that picture? Or about where is Tibet? ***(Reinforcing and Preparing)***

Calvin: I'd say in this area right here. ***(Constructing explanations)***

Dr. West: Okay.

Calvin: Right before the mountains and right under the . . . ***(Constructing explanations)***

Dr. West: Himalayas?

Calvin: Yeah.

Dr. West: Okay. India? ***(Reinforcing and Preparing)***

Calvin: Down here. ***(Constructing explanations)***

Dr. West: And the Tarin Basin? ***(Reinforcing and Preparing)***

Calvin: Up here. *Pointing at screen* ***(Constructing explanations)***
(Day 11, Field Notes, 00:50-01:00)

Dr. West asked Calvin to identify Tibet, India, and the Tarin Basin in Figure **5-2**. Tibet and India were labeled as part of the illustration; however, the Tarin Basin was not. In the discussion that followed Dr. West explained that sometimes questions arise that seem explicit, but require an explanation. Although his line of questions may seem simple, this excerpt shows that Calvin was knowledgeable of the illustration and how it was label, and could identify geographic locations that were not labeled in the illustration but were relative to geographic area.

In the following excerpt Dr. West asked Calvin a procedural question about how the elevation level was obtain. The graduate student also posed a question regarding disturbed and undisturbed days.

Excerpt 11d
Dr. West: …How did you get the elevation level? ***(Reinforcing and Preparing)***

Calvin: Cause we, we looked for the location we needed and we just pointed the pointy thingy on top of it and it gave us the elevation. ***(Constructing explanations)***

Dr. West: All right so it hasn't, it has an elevation readout above the screen and you just point on it.

Calvin: It's more than just a map it gives us the mean sea level, longitude and latitude. ***(Constructing explanations)***

Graduate Student: What does disturbed mean? ***(Reinforcing and Preparing)***

Calvin: …What does disturb mean? (calling student to attention)

Althea: Disturb means when there's more clouds in the sky… more thunderstorm clouds. ***(Constructing explanations)***

Dr. West: Okay so you have lots of thunderstorms, lots of cirrus and undesirable. Why is a thunderstorm a bad thing? It goes up tall. Has a great updraft. Why does <research pilot's name> not want to go flying around in a thunderstorm?

Althea: Because it will be more precipitation going on like hail and rain and that. And the wind will be a lot stronger. ***(Constructing explanations, Using inscriptions)***

Dr. West: So the wind might get in, the lightning might get in, the rain might freeze to his wings and the hail might pound him in the head. None of this is good. So good answer there. You want to keep him out of that stuff. Okay. Do you have questions on this? Next one.
(Day 11, Field Notes, 00:50-01:00)

Calvin's response to how the elevation level was obtained shows his understanding of how he engaged in collecting data. In his own way, he expressed that the software provided a readout as the cursor was placed over the cloud and that much more could be obtained from the use of software. This example shows what Calvin was able to take away from his engagement in the use of the imagery software. Note that also in this excerpt Althea was able to define the inscription disturbed as it pertained to the number of clouds in the sky. Furthermore, she able to express why flying through a thunderstorm would a disadvantage in their flight plans. Both students were able to successfully communicate their understanding of the concepts they were questioned about, thus showing how they were able to engage in the experience and their understanding of the some of the concepts. The next example provides an illustration of how Sharon was able to successfully respond to the reinforcement on things that were covered in the research group, but was unable to come to a conclusion on how the pilot of the glider plane would stay warm.

<u>Excerpt 11e</u>

Dr. West: What's the dis, yeah what's the disadvantage of flying through clouds? ***(Reinforcing and preparing)***

Sharon: Umm flying through the clouds he can fly into Mount Everest. ***(Constructing explanations)***

Dr. West: Yeah he can't see what he's doing. Yeah. We'll try to keep him out of clouds as much as we can.

Sharon: Yeah.

Dr. West: Okay. How does he keep from suffocating up there at 30,000 feet? ***(Reinforcing and preparing)***

Sharon: Oxygen mask. ***(Constructing explanations)***

Dr. West: Um, hm. How does he keep from freezing to death? ***(Reinforcing and preparing)***

Sharon: The temperature from the weather?

Dr. West: Yeah. How does he do it?

Sharon: I don't know.

Dr. West: Probably wears long underwear. He doesn't have an engine right? So he doesn't have a heater. And you have sunlight coming down into the glass cockpit to keep him a little bit warm. But once he's in the cloud it's going to be colder than heck. So he's probably going to be wearing about six sets of long underwear. So no heater. But he does have oxygen from the mask. And what type of day is he going to do this? ***(Providing Background information)***

Sharon: On a certain day.

Dr. West: On a certain day but what time of day? Afternoon, night?

Sharon: On an undisturbed day. ***(Constructing explanations)***

Dr. West: Well let's see. In the morning it's still cool, right? It heats up in the afternoon. ***(Providing Background information)*** So what does that do to the thermal . . . ***(Reinforcing and Preparing)***

Sharon: Afternoon. ***(Constructing explanations)***
(Day 11, Field Notes, 01:10-01:20)

Sharon responded to the disadvantages associated with flying a glider plane and the best time to fly. She confidently answered the questions dealing with the disadvantages to flying through clouds and the need for oxygen, however she struggled when probed about the temperature in the cloud and the best time to fly. What is important in this example is how the student was able to recall information relevant to the study, but could not make a connection to how the pilot would stay warm or what time would be best to fly to take advantage of the warmth of the day.

Each of the aforementioned excerpts demonstrates the students' understanding of the content through their responses to questions posed about their research. Throughout the experience students were involved within the experience at varying levels, and their understanding of some parts of their research did not indicate that they fully comprehended concepts relative to the analysis of the data. However, their ability to respond appropriately to questions about the research illustrated some level of understanding of the problem and how the data were interpreted. Analysis of excerpts 11a, 11d, and 11e show student understanding through discourse in how they explained and share their interpretations of the data. Analysis of excerpts 11b and 11c show student understanding of visual representations as they were able to apply background knowledge to answer their respective questions. Their responses do not show full proficiency in their understanding of the epistemological and cognitive processes it took to acquire the results of this study. Nevertheless, the students did show they understood key concepts of the project, and were able to successfully articulate their understanding when asked questions about their presentation and illustrations.

Interviews revealed information about the participants' background, level of participation in the research group, how they learn, and identity as a potential scientist. Although the interviews were not designed to assess students' science knowledge, responses did reveal students understanding of the project objectives and goals. The following excerpts are the students' responses to the objective of the research project during their interview. Student interviews were done on an individual basis, which provided good insight into how each student made sense of the project as they articulated the objectives of their experience. The first excerpt is Althea's response to what the research problem was or the purpose of the project.

> **Althea:** … it was to help Dr. <research pilot's name> who wants to fly the glider plane over Mount Everest. Because umm basically we just helped him a plan a route of which way he could go to get over Mount Everest because it's like some days he it wouldn't be possible for him to go…. Like he couldn't go during the night. He couldn't go during bad weather and like that basically.
>
> **Primary Investigator (PI):** Why wouldn't he be able to go during nighttime or bad weather?
>
> **Althea:** Umm, the night time it's not usually a lot of clouds out and if there are they're not too noticeable, cause that's what the glider planes needs, and umm he couldn't go on a bad weather day because the glider plane is like a hundred and fifty pounds and those type of clouds have extremely strong winds and bad precipitation so I don't think that would be the best time. (End of program personal interview. July 26, 2009)

Althea's response provided a synopsis of the research problem and also summarized a portion of the results. She was able to explain the purpose of the project or the research problem in addition to incorporating details about when it would be best for the pilot to travel. Her understanding of the disadvantages and ability to make connections to the lack of clouds, bad weather, and the weight of the plane shows that she was able to apply what she learned to construct and report basic findings from their research.

The following excerpt is Calvin's response to what description of the purpose of the project.

> **Calvin:** We got a chart, we got the height of the clouds and what times it's the perfect time to for Dr. <research pilot's name> to fly over Mount Everest…Dr. <research pilot's name> he wants to be the first man to ever fly over Mount Everest in a glider plane without an engine. And he, he already has one like some results from India I'm not sure from who, but he has the results from somebody else and he wants to put our results with his with their results to see if they combine together. And he will be able see if he will be able to actually fly over or not. (End of program personal interview. July 26, 2009)

Calvin spoke more about the process of trying to get Dr. Harold over Mount Everest. He provided additional detail about the aircraft and spoke about finding the cloud height and time of day. He also spoke about the collaboration of other researchers on the project. The excerpt is relevant in that it shows the extent to which Calvin understood that the research he participated and how the work they engaged in was collaborative. Sharon's understanding of the research project was similar to Althea and Calvin's responses.

The next excerpt is how she described the intended goal of the project was.

> **Sharon**: Basically, we had to study clouds because uh Dr. <research pilot's name> wanted to fly over Mount Everest. And we needed to know, we need for the cumulus clouds cause that was the we needed to know what type of day he could fly on and how it would effect his flight, the cumulus clouds. So we had to research clouds and like the length, and the width, and the height of the clouds and the thickness of the cloud and the diameter and figure out what day is the best day for him to fly on and basically how the clouds would effect him and his flying. (End of program personal interview. July 26, 2009)

In her explanation of the project, she mentioned how the type of day could affect the proposed flight pattern, the need to know details about clouds (i.e, length, width, and height), and the time of day. This example shows how Sharon interpreted the research objectives and the results. She mentioned the need for cumulus clouds and the need to know the time of day to help the glider pilot fly over Mount Everest. Her response also shows her understanding of the tasks needed to obtain the results. She was able to drawn connections regarding why knowing the dimensions of the cloud are necessary, however, she did not mention anything about how the data was incorporated into finding the results.

Yvette was the returning student to the group. She previously worked with Dr. West in 2006 on Bird Migration. In the following excerpt is Yvette's description of the 2007 Satellite Meteorology project.

> **Yvette:** Well this year, we were trying to. Well we were in meteorology, satellite meteorology. And we were trying to help a colleague of Professor <faculty mentor> fly a glider plane over Mount Everest. And so, we were just like we did a whole bunch of identifying cloud types and…Then we studied a lot of clouds and cloud images on MODIS and Google… the terrain on Google Earth and measure it, and did equations on Excel™. And that helped us determine which clouds were best to go through and how that would help his flight then. (End of program personal interview. July 26, 2009)

Notice that Yvette was the only student who explicitly named the tools that were used to collect and calculate the results. She also mentioned the identification of cloud types and how satellite imagery was used to obtain information about the clouds and the different terrains. Her description also included a reference to Excel™, which was used to calculate the data. While some of the individual responses contained more detail than others, each student was able to articulate a basic understanding of the research problem. In addition, their ability to clearly articulate the research objectives shows how they made sense of the project and the science concepts. The uniqueness of each response shows the level at which individual students were able to grasp what the research problem was. Though some students provided more detail in their responses, I believe each of them understood the overall research objective to some degree. Engagement in the cultural practices of satellite meteorology and their interactions within the group reflect their understanding of the research experience and showed how they were able to interpret data, construct explanations and communicate their findings.

In what ways do students engage in the cultural practices of science, such as using scientific discourse, interpreting inscriptions, and constructing explanations from evidence? (engaging in science practices, knowing science)

Students' engagement in scientific practices within the enacted curriculum was addressed in the section that focused on the enacted curriculum. Episodes of students' participation in the research group were used to provide insight into the ways the enacted curriculum provided opportunities for them to engage in scientific practices. The preceding sections highlighted instances within the enacted curriculum that showed students engaging in the cultural practices of science. This section provides an overview of the ways students engaged in those practices. Table **5-9** illustrates instance of students' daily engagement in scientific practices over the eleven-day research experience. Instances where a particular practice is absent are left blank. *A* is used to represent instances when students are actively engaged in the practice. Active engagement is used to define instances where students were engaged autonomously or were supported with minimal assistance. *P* is used to represent those instances where students were passively involved in the practice. Passive engagement is used to denote the instances that were didactic and where the students seem disconnected. In the succeeding paragraphs I illustrate the trends in the instances of practice globally across the eleven days the students met as a research group.

Table 5-9: Instances of Student Engagement in Scientific Practices.

		Week 1		Week2		Week 3		Week 4		Week 5		Week 6
		Day										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Scientific Practice	Analyzing data							P	P	P		
	Collecting data				A	A	A		P	A		
	Constructing explainations				A			P	P	A	A	A
	Making assertions							P	P	P		
	Making sense of the problem	A	A	A	A	A	A	P	P	A	A	A
	Publishing								A	A	A	A
	Using inscriptions		A	A	A	A	A	P	P	A	A	A
	Using instruments	A	A	A	A	A	A	P	P	A	A	

A= *active involvement*
P= *passive involvement*

Participation in the early portion of the experience (week one) was limited to asking questions about the research experience and getting acquainted with the instruments. For most of the students, this was their first experience working in Satellite Meteorology. During this time Dr. West engaged in a number of pedagogical practices such as providing background information on the research project, acclimating students to the instruments, making connections to real world applications, and defining terminology. Engagement in these practices introduced students to the cultural tools, practices, and the background of satellite meteorology and the objectives of the research experience. As students became familiar with these practices over the course of the six-week experience their engagement in some science practices increased over time.

Table 5-9 shows that throughout the research experience, participants in the Satellite Meteorology were almost always actively engaged in making sense of the problem, using inscriptions, and using instruments. However, instances where the students' seemed less involved occurred during the analysis of data in week four. In those instances where data analysis occurred, students show inactivity or were disconnected from the research experience. During these episodes participation was limited to students being instructed on what to input into Excel™, or engaged as listeners while Dr. West explained the analysis and findings. The excerpt below is an example of this.

> **Dr. West:** …Alright so 27 cases out of how many, we just counted this whole range here – this is 27 divided by 50 or 54% and then multiple by 100 to get a percent so there we are at 54% of the clouds we have measured are high enough to get us over Everest. So we simply went through and counted the ones that were over 9 kilometers high, counted them all and got a fraction, multiplied by 100 so that gets us – alright so we've got our first answer here. Put our answers in purple so they stand out. So that one we got answered – this cloud fraction business we are going to have to find out how cloud top varies with diameter and look for the intercept. ***(Analyzing data, Making assertions, Using inscriptions)***
> (Day 7, Field Notes, 00:40-00:50)

Field notes from day seven show that of the two hours and thirty minutes of the video, Dr. West is at the computer leading the analysis for a little more than an hour. Also noted in the field notes is that the teaching style was didactic and students were falling asleep. Patterns from the table also show that in cases where the participants were passively engaged they were less likely to use inscriptions and ask questions about the research. Although the students may not have had full understanding of the mathematical/statistical procedures and analysis, perhaps another approach would have allowed them an opportunity to participate in the analysis in a way that was more engaging. For instance, after students were introduced to the imaging software, cloud types, and geographical terrain the students were able to navigate using Google Earth and MODIS to collect and record data on different clouds. Table 5-9 showed that most occasions where students collected data showed the participants engaged in multiple scientific practices as they made sense of the data, used instruments, and used inscriptions throughout the process. These instances are not examples of students working totally independent. However, they do represent episodes where the students were actively engaged in data collecting and recording supported by the mentors. I provide the following abbreviated excerpt to show Dr. West guiding students through data collection.

> **Dr. West:** So look around for clouds that you think would be easy to tell where it is. Like that cloud for instance is close to a really crazy looking lake so you could probably find it on Google Earth – right? So pick one of those two. Pick the one you like and click on the center of the cloud and blow it up a little bit – hit the plus sign – that looks pretty good. Scroll up so you can see it again. There you go and there's your cloud. So you hover over the middle of your cloud and you put the black arrow on it – just the tip of the shadow, there you go bingo and there's your two numbers.
>
> **Sharon:** 2428 ***(Collecting data, Using instruments, Using inscriptions)***
>
> **Dr. West:** You are starting out with cloud x right?
>
> **Calvin:** What was it?
>
> **Dr. West:** 2428.
>
> **Sharon:** 131 for cloud 1 ***(Collecting data, Using instruments, Using inscriptions)***
>
> **Dr. West:** And then you go to the tip of the shadow. Go straight down central – perfect – ok.
>
> **Sharon**: 2423 – 124. ***(Collecting data, Using instruments, Using inscriptions)***
> (Day 5, Field Notes, 00:30- 00:40)

Note that the student is engaged in the data collection navigating the use of MODIS. Following the demonstration, students were allowed to work in groups to collect cloud data with support from Dr. West.

Patterns in Table **5-9** reflect that as students engaged in preparing for their presentation they were actively participating in the research using inscriptions and instruments when applicable. In the previous section it was pointed out that the graduate student mentor participated in the presentation preparation and had not allowed student to work on the computer to layout the sides. At first glance, this level of involvement could be perceived as hindering the students' engagement. Arguably, the graduate student mentor constantly involved the students by soliciting their thoughts and opinions. Thus, allowing tem to contribute to the presentation.

Participants in the Satellite Meteorology group had opportunities to participate in some of the cultural practices of science even though they were not completely immersed in all of the cognitive or epistemic processes of their research experience. As found when addressing the research questions that focused on the nature of the SEEMS experience, the graduate and faculty mentors were heavily involved in the research experience, often leaving room to question the level of engagement the students had in the research and how much were they able to take away. Though some of these instances were guided and students had very little autonomy within the research experience, this exposure was beneficial as it exposed the participants to science and ways of thinking using science. Opportunities that showcased students engaged in the cultural practices of science dealt with using satellite imaging, observing, collecting, collaborating, and publishing data. Their involvement in these scientific practices broadened the way they experienced science and to some extent provided an opportunity for them to have a greater understanding of science outside of traditional science learning while making connecting applications used in science their every day lives (Day 6 Group 2, Field Notes, 1:40-1:50; Day 9, Field Notes, 1:40-1:50).

Chapter 6

CONCLUSION

Overview: Research Problem

The need for a more scientifically literate population is the impetus for reform in science education. As a result the *National Science Education Standards* were developed to address some of the problems associated with making sure that " all students regardless of sex, cultural or ethnic background, physical or learning disabilities, future aspirations, or interest in science, *would* have the opportunity to attain high levels of science literacy" (National Research Council, 1996, p. 221). One way to implement this vision is to engage students in the cultural practices of science and to encourage them to make use of these practices in their everyday lives (American Association for the Advancement of Science, 1994; National Research Council, 2007).

Research questions guiding this study were arranged into two categories: those that investigated the Upward Bound Math Science (UBMS) Summer Experience in Earth and Mineral Science (SEEMS) research experience; and those that investigated participants' engagement in the research experience. Research questions that focused on the nature of the research experience sought to examine both the intended outcomes of the program, as well as the alignment of those outcomes with the enacted curriculum. The questions that focused on participant engagement sought to examine ways the participants made sense of science concepts and engaged in the cultural practices of science. In this chapter, I present a summary of the results, strengths and limitations of the study, and provide suggestions for future intervention strategies that might strengthen programs that purport to engage minority students in science research through authentic research experiences.

Summary of Results

Aligned with other research based recommendations, UBMS: SEEMS offers supplemental enrichment in mathematics and science courses (Barlow & Villarejo, 2004; Dirks & Cunningham, 2006; L. Jones, 1997; Stake & Mares, 2001, 2005), opportunities for mentoring (L. Jones, 1997; Stake & Mares, 2001; Thomson & Brooks, 1996), a support network (Barlow & Villarejo, 2004; Chatman, 2005; Dirks & Cunningham, 2006; L. Jones, 1997; Thomson & Brooks, 1996), and research writing opportunities (L. Jones, 1997). Moreover, UBMS: SEEMS offers a unique experience to groups traditionally underrepresented in science by providing these students with opportunities to work in a research based setting with scientists working "in the field."

While enrolled in supplemental courses in mathematics, science, English, and foreign language to help prepare them for their classes in the upcoming school year, students have opportunities to network with other students from schools across Pennsylvania and Alabama. The program also provides participants with exposure to science research through a subcomponent of the program that allows them to engage in on going science research under the supervision of an EMS faculty member at The Pennsylvania State University. In the research this study, students had an opportunity to work within the Satellite Meteorology lab where they were able to engage in certain cultural practices of the meteorology community. To culminate their experience in the program, students presented their research findings in a formal setting.

In order to determine the extent to which the program met its goal, I obtained statistical information from the UBMS website. The UBMS: SEEMS results note that:

> 7% of our students showed an increase of a quarter grade level in their score, or achieved the maximum score, on the Mathematics Section of the National Achievement Test.

> 82% of our students showed an increase of a quarter grade level in their score, or achieved the maximum score, on the Science Section of the National Achievement Test.
>
> 89% of our students received an above-average grade in their Mathematics class during the school year.
>
> 87% of our students received an above-average grade in their Science class during the school year
>
> 100% of our students are accepted into postsecondary education.
>
> 93% of our students enroll in postsecondary education.
>
> 81% of our students enrolled in postsecondary education graduate with a Bachelor's degree; 76% graduate with a Bachelor's degree in a math- or science-related field. (The Pennsylvania State University: Office of the Vice Provost for Educational Equity, 2009b)

These results show particular success rates of participants in the UBMS program. The program does not boast that these results are due solely to students' enrollment in this program: external measures may have also contributed to their success. Also important to recognize in these findings is the absence of specific information regarding the SEEMS research experience and its impact on students' interest in/exposure to science within the science research setting.

The SEEMS component of UMBS aims to engage minority students in research to strengthen/develop their science management skills through exposure to resources they would otherwise not have access to, and to promote their successful entry into post secondary education in STEM fields. The findings of this study provide insight into the experience of the Satellite Meteorology group, as an illustrative case of minority students' activities learning science through research experience. Because each SEEMS research project is designed by the participating faculty mentor and/or graduate student in EMS, thorough analysis of the extent to which the enacted curriculum of *all* research experiences successfully met their intended goals cannot be reported. However, inferences can be made about the intended program goals through analysis of the intended objectives and final presentations of each group.

Analysis of video data and field notes showed that students in the Satellite Meteorology group engaged in a research experience that allowed them to use and strengthen various practices of science. Students did engaged in using MODIS and Google Earth. As ascertained through interviews with these students, the nature of this experience was quite different from their high school science classroom experiences. In sum, through their *hands on* participation in the research group, these minority students were able to engage in certain cultural practices of scientists in the EMS field.

Two mentors, Dr. West and his graduate student, facilitated the nature of the students' engagement in this research experience. To some extent, the students were given opportunities to participate in the following cultural practices: analyzing data, collecting data, constructing explanations, making assertions, making sense of the problem, publishing, using inscriptions, and using instruments. Although at times their engagement was heavily guided, the overall exposure to this research environment provided an opportunity for these minority students to experience science in an authentic manner. Arguably, their participation positions them as what the educational research literature might call novice *apprentices*, with acculturation into an environment occurring over time as students begin to *legitimize* themselves within the community of practice (Lave & Wenger, 1991). As they engaged in the research experience, these students showed increased understandings of the project through their appropriate use of inscriptions and tools. In addition, engagement in the research process through their sense making of the research problem, its data collection methods, and the construction of explanations to support claims in their presentation are all examples of ways these students were able to show their understanding of science concepts. For example, Table **5-9** illustrates how students actively participated in the research experience (except during the data analysis phase). Furthermore, the explanations they constructed during their reinforcement session with Dr. West showed their understanding of the science concepts.

Contributions to the literature

As outlined in Chapter 2, barriers commonly associated with the disproportionate underrepresentation of racial/ethnic minorities in STEM disciplines have primarily focused on increasing the representation of these learners by examining the limitations surrounding access associated with schooling. As a result, programs designed to address these salient issues often provide learners with exposure to mathematics and science enrichment opportunities, opportunities to network, advising and counseling, and mentorship (Barlow & Villarejo, 2004; Chatman, 2005; Dirks & Cunningham, 2006). These efforts, though important, tend not to focus on students' sociocultural ways of knowing and doing science. Arguably, a sociocultural approach would recognize the need for teaching and learning science in ways that focus on how students make sense of and apply science content knowledge. While addressing issues relative to access associated with schooling is a necessary component of moving beyond the barriers associated with these groups, approaching minority student participants from a sociocultural approach broadens the scope to include the construction of knowledge within social and cultural settings. An understanding of how minority students express themselves and how they make sense of science should be incorporated along with an understanding how socioeconomics and personalities shape their approach to science learning. Programs like this one would benefit from both bringing students into scientists' culture and working to acknowledge the students' own unique cultures.

A key feature of this study focused on the sociocultural aspect of how minority students engage in the cultural practices of science and how they made sense of these practices and applied them to a research problem. My contribution to the body of literature surrounding underrepresented groups in science, authentic science research experiences, and sociocultural approaches to knowing and doing science provides a careful look at actual practice and not an ex post facto survey that generalizes students' interest in this "different science." Few studies look at students enrolled in science enrichment programs to examine how they actually engage in the research experience. In this study, I focused on the actual engagement during a science research experience and how these minority students made sense of that experience.

Program observations and suggestions

The SEEMS program is designed so that minority students have an opportunity to participate in one EMS discipline at The Pennsylvania State University. In this case, students participated in studying Meteorology and thus were exposed to the cultural practices within this discipline. While aspects of this experience provided them with opportunities and exposure to science unlike their high school science classes, I am not sure if the direction/approach to this task best suited this particular group of minority students. Because the students enrolled in the experience were seen not to have had the depth of content knowledge needed to carry out the research experience alone, portions of the experience became heavily didactic, centered on content knowledge acquisition without regard for the experiences they brought to the situation. Observations of the students' daily interactions with their two mentors show repeated instances where the focus is on learning material similar to that taught in an entry level college course. A more appropriate approach to engaging these students in the research experience would incorporate an effort to bring their cultural knowledge and understandings into the experience.

The findings from this study echo what other researchers have noted about authentic learning programs efforts: program goals need to be carefully examined to assure that active student participation in science research occurs. Situated in the context of a science enrichment program, and similar to other programs that have some focus on providing participants with opportunities to engage in science research, UBMS: SEEMS is structured in a way that places much emphasis and engagement on teaching science content to students engaged in the research experience. What can be implied from the findings within the enacted curriculum of this study is that research mentors did not fully understand the importance of providing these minority students with opportunities to *truly* engage in the research experience by giving them some autonomy within the research group, recognizing and building upon who they were and what they knew as learners.

Clearly, the research mentors have to teach science content to members of the research group. However, my point is that in addition to this necessity, programs like SEEMS should also focus on incorporating aspects of these students as culturally and socially relevant learners. This is not to say that these minority students, on some level, did not gain anything from their experience. However, their limited participation within the research group as a result of overbearing instruction and lack of substantive opportunity for them to engage in the experience in ways that are culturally and socially relevant does not align with the program's hope to connect knowing and doing science with real-world experiences.

As a Black woman who taught high school science at an all Black, Catholic high school, understanding where these SEEMS students *come from* and appreciating relevant aspects of their cultural lives is fundamental to their success. Those who choose to try and create equitable learning environments for poor, urban students need to recognize how important it is to approach teaching and learning science from a culturally sensitive perspective. For example, the excerpt in Chapter 5 describes Calvin's mis/use of the word *high* to describe the shadow height with respect to its location on the side of a mountain. The faculty mentor then attempts to correct Calvin's apparent misunderstanding. Actually, I believe that Calvin understood that shadows have no physical height, but did not understand his inappropriate use of the term *high* to describe the location of the shadow with respect to the mountain. The un-asked and un-answered question here, is what did Calvin *mean* when he said *high*? While this example may seem trivial, unasked questions regarding *how* Calvin was using the term ignore the possibility that he may have been using his everyday discourse to correctly answer the question at hand. This is not to say that students should be permitted to ignore appropriate use of terminology. However, in situations like these, opportunities for students to express themselves in ways that help them gain full understanding of the concepts should take priority, because doing so allows them to apply their own way of making sense of the concepts and how they are applied. Once we establish that Calvin *does* understand the situation, we can then teach him the appropriate terminology for explaining it.

Among other suggestions and observations, broadening the scope of the SEEMS program to allow exposure to multiple disciplines would allow minority students to gain a better understanding of the many disciplines within Earth and Mineral Science and to grow from being exposed to the cultural practices of these other disciplines. Furthermore, broadening the scope of the program to incorporate other institutions of higher learning could create a broader network of mentors for program participants and different perspectives on learning. Each university has its own culture and way of doing things. Exposing students to different ways of doing science across multiple university cultures would allow them to see how these practices are similar or different.

The mentoring piece of the UBMS: SEEMS experience appears to be severely underutilized. Although not a primary focus of this study, mentoring has played a significant role in sustaining the interest of and retaining underrepresented groups in the STEM disciplines. More attention should be given to this aspect of the research experience. Minority students spend six weeks building a working relationship with researchers in the field. If the nature of this experience is positive, consideration should be given to allowing students to continue working with their previously assigned mentor as it might enhance their interest in the field while helping to foster a greater connection between the student and faculty mentor.

Clearly, aspects of the SEEMS research experience provide positive opportunities for minority students to engage in science research. However, when it ends, these students leave the program (and the Penn State campus) and return to their respective schools, where they revert to learning science in their local classroom environments. The stark differences between the students' summer experience and their high school learning experience needs to be addressed.

Another suggestion for the future of this program would be to encourage or provide opportunities for the active participation of scientists in high school students' science education and the active role of high school science teachers in higher education science research opportunities. This exchange could help bridge the gap between science and school and draw on the strengths of both areas of expertise in service to each other. Similar to Buxton's (2006) idea of a contextually authentic science perspective, aspects of canonical science and sociocultural perspectives of students would be combined to create meaningful science experiences for students. Active collaboration between scientists and teachers in designing high school science curriculum and instruction might help to alleviate the extreme differences between science classrooms and science laboratories. Furthermore, active participation and encouraged collaboration between these teachers and researchers might help to promote research-based efforts to improve teaching, learning, and exposing high school students to science in authentic ways informed by research and practice.

Limitations of study

One of the limitations of this study pertains to the circumstances in which the experience occurred. For example, the scope of this study was not large enough to generalize its findings. As such, findings from this study are more evaluative of the SEEMS program than of programs in general designed to create equitable situations for underrepresented groups. Implications for future research include a need for common educational research approaches across science disciplines and institutions of higher education to investigate knowledge that can be generalized regarding programs like this one designed to promote equity.

Among other limitations of this study is the method of measurement for the SEEMS research experience. Programs like this need measures of assessment that are designed to examine whether their structured experiences have a positive impact on students' persistence and retention in the field. UBMS: SEEMS is a federally funded program that provides disadvantaged high school students with opportunities to engage in the cultural practices of science research while participating in a six-week summer program at The Pennsylvania State University. Although much of the research experience described here resembled the didactic pedagogical practices seen in traditional classrooms, the program has garnered student interest, given that three out of four participants in this study preferred their SEEMS experience to their high school science class experience. It is not hard to imagine, for example, that being away from home, in this new environment (at Penn State), with so many new personal and experimental encounters has just as much to do with these preferences.

Several layers and components in the intended SEEMS curriculum address common barriers associated with underrepresented groups in STEM disciplines. While other aspects of the program provide unique research experiences and attempt to foster the development of higher order thinking skills, future research should focus on equitable measures of assessment for the program. For example, assessment reports could focus on aspects that illustrate the extent to which minority students have positive experiences within the program and how this information might best inform the governmental departments that fund the program. Thorough reports on how the program best serves minority students would provide insight into improvements that are needed to help address the particular needs of these learners, and the possible need for additional funding to support professional development and other such related opportunities.

This study sought to evaluate the nature of the SEEMS program and to measure how students engaged in science practices. While multiple sources of data added strength to the findings of the study, one important limitation of this work is the absence of potential survey data. Each year, SEEMS distributes a pre- and post- survey instrument to students, with questions ranging from student demographics and interest in different disciplines to their knowledge of the college application process (See Appendix I and Appendix J). In 2007, when I began collecting data for this study, I was able to add five questions to this survey instrument pertaining to student's high school science experience, impressions of the nature of science practices, and views of themselves as scientists. My purpose for adding these questions to the instrument was to capture a broad understanding of how the entire UBMS class responded to the aforementioned information before and after the program. Unfortunately, the items were added only to the pre-survey instrument, and as a result, I chose not to include the information from the instrument in the study, as I would not have been able to compare their pre- and post- program perceptions.

Another limitation is the absence of analysis done on the students' actual end-of-program presentations. These culminating presentations were scheduled to be broadcast on the UBMS website. However, due to technical difficulties, the transmission failed. After several unsuccessful attempts at trying to acquire this video for analysis, I decided to use the students' presentation preparation period, PowerPoint presentations, and interviews to inform the findings of the study.

Finally, as the sole investigator of this study, I was only able to study one group within the context of the SEEMS research experience. Although the program has an alternative research experience – Summer Experience in the Eberly College of Science (SEECoS) – the vast distances in building locations on campus and the lack of personnel did not allow me to study both experiences. Moreover, between the SEEMS and SEECos programs there were a total of eighteen groups spread across approximately five building locations on Penn State's campus.

Recommendations for future research would include a research term studying multiple groups within the context of multiple departments and programs. Furthermore, I suggest looking at programs that may offer research experiences using cross-disciplinary approach or supporting collaboration across groups/ universities.

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Appendix A

SAMPLE FIELD NOTES

Time	Video Description	Initial Codes	Notes
00:00-00:10	Setup Recaps from the previous day. Objectives for the day Collecting data in Spreadsheet. Defines Tarin Basin Demonstrates what students should be doing as far as collecting data	Providing Background information Defining Terminology Collecting Data	West leads
00:10-00:20	Using Google earth to identify clouds over the slopes Breaks up group at 13:55. so that students can work in pairs at two separate computers. Students will work at opposite ends of the list to cover more ground. Students begin to identify items in Google earth with the help of Dr. West West assists students in their view of Google earth	Using Instruments Collecting Data Using inscriptions Defining terminology	Dr. West leads. Calvin works on computer to include information fed by Dr. West.
00:20-00:30	Dr West provides explanations of what is being looked for and why. Google Earth and identifying clouds and where they are located Identifying terrain using Google earth.	Providing background information Collecting Data Using Inscriptions Collecting data Using Instrument	
00:30-00:40	Collecting Descriptive data from Google earth Sharon swaps with Calvin to lead Dr. West helps student identify items seen in Google Earth. Identifying clouds in Google earth	Collecting Data Making sense of the problem Responding to questions Using instrument	Calvin working to identify clouds in different areas on Google Earth
00:40-00:50	Dr. West works with students to identify key clouds and other elements within Google earth Sharon tries to make sense of the illustrations she sees on the screen Dr. West implements a rule of identifying clouds	Collecting Data Making Assertions Using Instrument	

00:50-1:00	Dr, West and Sharon try to make sense of the clouds they see on Google Earth. Student struggles with cloud identification. Making sense of illustrations as it pertains to clouds and weather in Google earth. Dr. West leading/assisting student	Collecting Data Making Assertions Using instruments	Student trying to make sense of clouds. Does she really know what she's looking like

Appendix B

INFORMED CONSENT

INFORMED CONSENT FORM FOR SOCIAL SCIENCE RESEARCH
The Pennsylvania State University

Title of Project: Investigating the Influence of an Authentic Science Experience on Minority Student Interest in Science and Science Careers

Principal Investigator: Stephanie Danette Preston, Graduate Student
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Advisor: Dr. Carla Zembal-Saul
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Other Investigator(s):

1. **Purpose of the Study:** The purpose of this study is to investigate the influence of an authentic science expereince on minority students' identity as a science learner/ participant in the scientific community, interest in science and science careers, and their understandings of the nature of scientific practices. The purpose of this study is also to examine how the participants of the SEEMS program engage in the learning community that develops around the research experience and how their participation may change over time.

2. **Procedures to be followed:** You will be asked to participate in an audio taped interview. Following the interview you may be contacted via email to follow-up on answers given in the initial interview.

3. **Discomforts and Risks:** There are no foreseeable risks in participating in this research beyond those experienced in everyday life.

4. **Benefits:** The benefits to you include learning more about yourself as a researcher by participating in this study. You might have a better understanding of how the program you are participating and the guidance that you give throughout the program may influence minority students's identity as a science learners, their participant in the scientific community, their interest in science and science careers, and their understandings of the nature of scientific practices

   The benefits to society include a better understanding of the influence that an authentic science experience would have on minority student interest in science and the pursuit of science careers. It would also provide a lens on how participants engage in the learning community that develops around an authentic research experience where they are immersed in the culture of science and how does that participation may change over time.

5. **Duration/Time:** It will take about 30 minutes to complete the interview. Subsequent interviews which may be conducted via email will take no more than 15 minutes to answer.

6. **Statement of Confidentiality:** Your participation in this research is confidential. Your name will be coded using pseudonyms so that no identifiable information will link you to the program other than a coded sheet that will be kept by the person in charge. The data will be stored and secured at 158 Chambers Building in a file cabinet located in a locked office. Transcripts of the interview will be stored on a password protected computer. Your confidentiality will be kept to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties. In the event of a publication or presentation resulting from this research, no personally identifiable information will be shared. The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, Penn State University's Social Science Institutional Review Board, and Penn State University's Office for Research Protections.

7. **Right to Ask Questions:** You can ask questions about this research. Contact Stephanie D. Preston at (814) 867-5516 with questions or if you feel this study has harmed you. You can also call this number if you have complaints or concerns about this research. If you have questions about your rights as a research participant, or you have concerns or general questions about the research, contact Penn State University's Office for Research Protections at (814) 865-1775.

8. **Voluntary Participation:** Your decision to participate in this study is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent form for your records.

____

Participant Signature Date

____

Stephanie Danette Preston- Researcher Date
or Name of Person Obtaining Consent

Appendix C

RECRUITMENT LETTER TO STUDENTS

Invitation to Participate

(Script to be followed by Program Directors)

Title of Project: Investigating the Influence of an Authentic Science Experience on Minority Student Interest in Science and Science Careers

Principal Investigator: Stephanie Danette Preston, Graduate Student
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Upward Bound Math & Science (UBMS)/ Summer Experience in Earth & Mineral Sciences (SEEMS) has the opportunity to be involved in an experiment that is designed to find out what part an authentic science research experience has on your identity as a science learner/ participant in the scientific community, interest in science and science careers, and their understandings of the nature of scientific practices.

You can choose to participate in this experiment, or you can choose not to. It is up to you.

If you choose to participate, you may be selected for a focus group and you may be interviewed. You will be asked to talk about your UBMS/SEEMS experience, your interest in science, and your interest in authentic science research. Your words will be audio-recorded for the purpose of this study and your name will be coded using pseudonames so that no identifiable information will link you to the program other than a coded sheet that will be kept in a locked office only available to the researcher. The tape records also will be saved and locked in the researcher's office cabinet, and will be destroyed by 2011. No one can get access to the records except the researcher and her staff. If you speak about the contents of the focus group outside the group, it is expected that you will not tell others what individual participants said. If further analysis, of your interview statements, is needed the researcher will then contact you via phone or email, which ever method of communication is best for you. Your confidentiality will be kept to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.

At the end of the study the researcher will analyze the information you have provided and will use the data to inform her research and future revisions of the UBMS/SEEMS program.

If you choose **not** to participate, you will not be required to do anything additional. If you choose to participate today, and then decide later that you would rather not, you may stop at any time. Stopping will not your position with the UBMS/SEEMS program. However, you **can not** decide now **not to participate**, and **then** decide **to** participate later. You can stop at any time, but if you are "in," you must be "in" from the beginning.

If you would like to participate, you will need to make sure that your parent(s)/guardian(s) have signed and returned the parent(s)/guardian(s) consent form. If they do not want you to participate, they do not have to sign or return the form.

There are no consequences, if you choose not to participate.

I can only pass out assent forms to those of you whose parent(s)/guardian(s) have already returned their consent forms. I'll come around to pass out the forms. If you don't want to participate let me know, and I won't give you a form. I'll put your name on a list of students who will not be participating.

Thank you

Appendix D

INFORMED ASSENT

ASSENT FORM FOR SOCIAL SCIENCE RESEARCH
The Pennsylvania State University

Title of Project: Investigating the Influence of an Authentic Science Experience on Minority Student Interest in Science and Science Careers

Principal Investigator: Stephanie Danette Preston, Graduate Student
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1. **What is the Project About?** You are being asked to participate in a research study. Studies like this one help teachers' find out more about how being involved in an actual science researcher project affects your decision to pursue science careers. It also informs the program directors of UBMS/SEEMS of things that you feel are helpful in helping you to learn more about science through research. This form will tell you about the study to help you decide whether or not you want to participate. You can ask any questions you have before making up your mind. You can think about it and discuss it with your family or friends before you decide. It is okay to say "No" if you don't want to be in the study. If you say "Yes" you can change your mind and quit being in the study at any time without getting in trouble. If you decide you want to be in the study, an adult (parent, guardian) will also need to give permission for you to be in the study. If your parent said not to participate in this research, you should tell the investigator, Stephanie Preston.

2. **What is the Research About?** The research will help researchers understand the link between students' interest in science and their exposure to authentic scientific researcher. It will also help to link the nature of students' understandings of scientific practices and their exposure to authentic scientific research.

3. **Procedures to Be Followed**: If you choose to participate, you may be selected for a focus group and you may be interviewed. You will be asked to talk about your UBMS/SEEMS experience, your interest in science, and your interest in authentic science research. Your words will be audio-recorded for the purpose of this study. If further analysis, of your interview statements, is needed the researcher will then contact you via phone or email, which ever method of communication is best for you.

4. **How long will it take me?** The interview portion of this study will last about 20 minutes long (but could be shorter). However, this section could be much longer if he/she chooses to participate in any follow-up that may be needed. Subsequent interviews which may be conducted via email will take no more than 15 minutes to answer. The focus group session of this study may last about 45 minutes to an hour. If you feel uncomfortable answering any of the questions, you can stop at any time.

5. **Risks if I Participate?** Your participation in UBMS/SEEMS in the future will not be affected if you participate or decide that you do not want to participate. If you decide that you do not want to participate, it is of no cost to you. When I get the results back from the study, I will be happy to share them with your class. It feels good to be involved in a project to help make things better.

6. **Statement of Confidentiality:** All of the responses given in the interview and focus group will remain confidential. Your name will be coded using pseudonyms, or masked names, so that no identifiable information will link you to the program. The Principal Investigator will analyze the data, but never match your responses with your name or other information about you when summarizing, presenting, or publishing the results of the research. Your words will be audio-recorded for the purpose of this study and your name will be coded using pseudonyms so that no identifiable information will link you to the program other than a coded sheet that will be kept in a locked office only available to the researcher. The tape records also will be saved and locked in the researcher's office cabinet, and will be destroyed by 2012. If you speak about the contents of the focus group outside the group, it is expected that you will not tell others what individual participants said. For the email part of the study, your confidentiality will be kept to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties. The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, Penn State University's Social Science Institutional Review Board, and Penn State University's Office for Research Protections.

7. **Right to Ask Questions:** You can ask questions about this research. Contact Stephanie D. Preston at (814) 867-5516 with questions or if you feel this study has harmed you. You can also call this number if you have complaints or concerns about this research. If you have questions about your rights as a research participant contact Penn State University's Office for Research Protections at (814) 865-1775.

8. **Payment for participation:** There is no monetary payment for participation in this study, however pizza will be provided during the focus group.

9. **Voluntary Participation:** Your decision to participate in this study is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

Thank you for considering your involvement in this research. You will be given a copy of this signed and dated agreement form for your records.

If you agree to take part in this research study and the information outlined above, please print your name stating that you give your permission to be audio, digitally, or video recorded and sign your name and indicate the date below.

____ gives his/her permission to be (audio/digitally, or video) taped.

______________________________________ ____________________
Participant Signature Date

______________________________________ ____________________
Stephanie Danette Preston-researcher Date

Appendix E

RECRUITMENT LETTER TO PARENTS

PENNSTATE

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Stephanie Danette Preston, Graduate Student
The Pennsylvania State University
158 Chambers Building
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(814) 867-5516; sdp163@psu.edu

May 15, 2007

Dear Parent/ Guardian:

Congratulations on your child's acceptance/ participation in the Summer Experience in Earth & Mineral Sciences (SEEMS) program at Pennsylvania State University. I hope that your child has a rewarding experience in the classroom and on campus!

My name is Stephanie Preston and I am a 3rd year Doctoral Candidate in the College of Education here at Penn State. Currently, I am seeking research volunteers who are participants of the SEEMS program to participate in a research study I am conducting. The research is entitled *Investigating the Influence of an Authentic Science Experience on Minority Student Interest in Science and Science Careers*. Part of my research involves asking participants in Penn State's Upward Bound Math & Science program to talk about their UBMS/SEEMS experience, their interest in science, and their interest in authentic science research. You can find additional information on my study on the attached parental informed **consent form that would be signed and returned only if you wish to "opt" your child OUT of my research**.

The purpose of this letter is to inform you of the research opportunity and to obtain your permission as a parent/ guardian that would allow your child to participate. Enclosed with this letter you will find two copies of the "Parental Opt Out of Research" informed consent form, as well as one copy of the "Child Assent" form that your child will be asked to sign if you agree to the research and he/she decides to participate in this study (this form is just for your review and records).

<u>Instructions for completing the "Parental Opt Out of Research" form</u>:

If you **AGREE** to allow your child to participate, **do nothing** (just keep all copies of the attached forms).

If you are **OPPOSED** to your child participating in this study, **complete and return the attached form to notify me. Pull last page** from the Parental Opt Out of Research form, **complete it,** and **return it via postage paid envelope within one week of** receiving the information about this research. **If I receive the signed Parental Opt Out of Research form, your child will NOT BE INCLUDED IN MY RESEARCH.**

If you would like to review the research results, I would be happy to share the results with you once the data has been analyzed. The results of this study will be made available to you upon written request. You would only need to see me an note via email so that I can keep track of your request. My email address is sdp163@psu.edu. Please email your request in writing and state that you wish to receive the results of the research once the data anlaysis is completed.

Thank you in advance for your help. I hope your child enjoys his or her time at Penn State!

Sincerely,

Stephanie Danette Preston, Doctoral Candidate

Appendix F

PARENTAL "OPT OUT"OF RESEARCH INFORMED CONSENT FORM FOR SOCIAL SCIENCE RESEARCH

PARENTAL "OPT OUT" OF RESEARCH INFORMED CONSENT FORM FOR SOCIAL SCIENCE RESEARCH
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(814) 865-0827; cxz12@psu.edu

1. **Purpose of the Study:** The purpose of this research study is to investigate the influence of an authentic science expereince on minority students's identity as a science learner/ participant in the scientific community, interest in science and science careers, and their understandings of the nature of scientific practices. The purpose of this study is also to examine how the participants of the SEEMS program engage in the learning community that develops around the research experience and how their participation may change over time.

2. **Procedures to be followed:** If you allow your child to participate, he/she may be selected to participate in a focus group and he/she may be involved in an interview. He/she will be asked to talk about their UBMS/SEEMS experience, their interest in science, and their interest in authentic science research. His/ her words will be audio-recorded for the purpose of this study and his/her name will be coded using pseudonames so that no identifiable information will link them to the program other than a coded sheet that will be kept in a locked office only available to the researcher. The tape records also will be saved and locked in the researcher's office cabinet, and will be destroyed by 2012. If he/she speaks about the contents of the focus group outside the group, it is expected that he/she will not tell others what individual participants said. If further analysis, of his/her interview statements, is needed the researcher will then contact him/ her via phone or email, which ever method of communication is best. His/ her confidentiality will be kept to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.

3. **Discomforts and Risks:** There are no risks to your child related to participating in this research beyond those experienced in everyday life. If your child feels uncomfortable answering any of the questions, he/she can stop at any time.

4. **Benefits:** The results of this research will be used to benefit society by providing a better understanding of the influence that an authentic science experience can have on minority

student interest in science and the pursuit of science careers. It may also provide a lens for how participants engage in the learning community that develops around a research experience.

5. **Duration:** The interview portion of this study will last about 20 minutes long (but could be shorter). This involvement could be much longer if he/she chooses to participate in any follow-up research opportunities that will be offered. Subsequent interviews which may be conducted via email will take no more than 15 minutes to answer. The focus group session of this study may last about 45 minutes to an hour.

6. **Statement of Confidentiality:** Your child's participation in this research will remain confidential. The recorded audio and video records and transcripts will be labeled using dates, time, and words or phrases to summarize its content. These tapes will be stored in a locked office, filing cabinet, or on a password protected computer. The original audio and video records shall be destroyed by 2012. In the event of a publication or presentation resulting from the research, no personally identifiable information about your child will be shared. Transcripts of the interview and focus groups will be kept on the researcher's password protected notebook computer. If your child speaks about the contents of the focus group outside the group, it is expected that he/she will not tell others what individual participants said. The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, Penn State University's Social Science Institutional Review Board, and Penn State University's Office for Research Protections.

7. **Right to Ask Questions:** You can ask questions about this research. Contact Stephanie D. Preston at (814) 867-5516 with questions or if you feel this study has harmed you. You can also call this number if you have complaints or concerns about this research. If you have questions about your rights as a research participant contact Penn State University's Office for Research Protections at (814) 865-1775.

8. **Payment for participation:** There is no monetary compensation available to you or your child for his or her participation in the research. However, if selected for the study pizza will be available during the focus group sessions.

9. **Voluntary Participation:** Your decision to permit your child to participate in this research is voluntary. Your child can stop participating at any time. Your child does not have to answer any questions he or she does not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits your child would receive otherwise.

IF YOU CHOOSE **NOT TO ALLOW YOUR CHILD** TO PARTICIPATE **PLEASE** SIGN **BELOW AND FILL OUT THE NECESSARY INFORMATION**

If you **DO NOT** agree to the information you have read and **DO NOT** wish to allow your child to participate in the research, please print your child's first and last name below and sign both copies of the parental consent forms provided to you. Then, please return one signed copy to the person collecting the forms, or **within one week of receiving the information about the research if mailing the forms through US Postal Service**.

Print First and Last Name of Your Child

Parent or Guardian Signature Date

Stephanie Danette Preston – Principal Investigator Date

Appendix G

STUDENT INTERVIEW PROTOCOL

Part I: Establishing Interview Setting	
Primary Interview Questions	**Follow-up with Probes/ Prompts**
IRB in place-discuss content	
Describe the purpose of the study	
Part II: Identify Participant's Background	
Do you have a role model who has encouraged to participate in science related activities?	Does he/she have a science related occupation?
	Is he/ she pursing a degree in a science, math, or engineering field?
Why is science easy/ difficult for you?	
How did you become involved with the UBMS program?	Did anyone in your family attend?
	Were you recommended by at teacher? Administrator? Did anyone in your family attend?
	Were you recommended by at teacher? Administrator?
Is this your first year in the UMBS program?	What was your experience with the program in the previous year (s)?
Is this your first EMS experience?	What was your previous experience like? Was it through a summer program or class? How does this compare to your previous experiences? Who did you work with in the previous year? What was your project? Did you enjoy what you did?
What science course have you taken?	What is your experience in science class like?
	How is science taught at your school?
	Have any of your science classes resembled your experience in the SEEMS program?
Part III: Authentic Science Inquiry- Is it really present? Can the participants identify the difference?	
Describe the project you were involved in?	What specific area of Earth and Mineral Science does this project fall under? Were you familiar with this area?
What is your role in the group?	Were you assign a role or did you select your role?
How involved would you say you were in the group's daily activity?	If not too involved, why?
What was the purpose of your project? (What is your research question?	What part did you play in designing the research question for your project? Did everyone in your group participate? Was it given to you? Were you able to decide?
What role did you play in designing the experiment?	Did your group receive help in designing the project?
	a. What are your variables? b. Was the experimental design given to you?

How are the results of the experiment to determined?	How are they reported? Was someone assigned to this portion or was the whole group responsible?
How were the results analyzed?	Did you throw any information out? Did you compare your results to anything?
PART IV: Participants and the Learning Community	
When learning new science concepts how do you attempt to understand them?	Do you connect them to previous experiences?
	Real world experiences?
If you come across a concept you do not understand what steps do you take?	Would you find relevant sources to help you understand the concept? Would you ask another student for help?
If you make a mistake, do you try to find out where your error was?	Would/ did you later attempt to solve the problem or answer the question again?
Do you see yourself as a partner in your research group?	Did/ do you feel that what you have to contribute is important?
PART V: The Research Experience and Participants: Identity Career Choice, Understanding of Science Practices	
Why is science important to you?	Can you see yourself as scientist?
Does science shape any part of who you are?	Can you see examples of science in your everyday life?
	What are they? How important are these things to you?
What are your science grades like in school?	If you had your choice would you choose to take courses in science? Why
Would you pursue science as a career?	What would you choose and why? If you chose not to pursue a science related field, why?
What do you think science really is?	Is that different from what you thought prior to this experience?

Appendix H

MENTOR INTERVIEW PROTOCOL

Part I: Establishing Interview Setting	
Primary Interview Questions	**Follow-up with Probes/ Prompts**
IRB in place-discuss content	
Describe the purpose of the study	
Part II: Identify Mentor Background	
What is your educational background?	Degrees, Area(s) of concentration, Research Interest
How did you get involved with the SEEMS program?	What was working with the program been like?
What do you feel the UBMS/SEEMS project offers that is different from regular high school science?	Do you think traditional classrooms emulate the laboratory environment
Part III: Authentic Science Inquiry- Is it really present? Does this mentor really push for it to be a true authentic experience?	
What were the topics of your previous students projects?	How much autonomy did the students have in choosing the topics for the research projects?
At the beginning of the project, What level of knowledge did the participants have in the area you were working?	What information did you provide?
	What level of knowledge did the participants leave the program with?
Do you give a formal orientation to your lab?	What does that entail?
How involved would you say you are in the group's daily activity?	What was your level of participation in the group's daily activities?
How do students work in the labs?	Are they assigned to groups? Are they broken up so as to give each student a particular task to master?
How much autonomy did the participants have in designing the research question or how they would attempt to answer the research question?	What was the level of participation of the participants in the process of planning the design of the experiment, implementation of the design, and planning the measures for the experiment?
How is data for the participants' project collect?	Analyzed? Is the data transformed into another form? By whom?
Do the research participants draw on the evidence they have to make claims about their work?	Are they encouraged or do they readily do this?
Do you encourage the participants to compare their results to the results of other scientist to validate their claims?	
PART IV: Authentic Science Inquiry- Epistemology Beliefs of Students	
Can the participants describe the project they are involved in ?	Can the participants describe the project they are involved in ?

How do you address theory with the participants?	Are the participants encourage to research the area they are working in?
Do you encourage the participants to communicate and share ideas amongst the other members of their cohort?	
PART V: Mentor's Thoughts on What is Being Accomplished	
What do you feel is the highlight of the UBMS/SEEMS program?	
Do you feel the participants walk away with better understanding of what science is or how science is done?	What is your evidence?
Do you feel the participants in the program are capable of authentic scientific work?	
Is this SEEMS experience an authentic science experience?	Does it give the participants a true look at what scientist really do?
	Does it give a true sense of how collaborative science is?

Appendix I

SEEMS PRE-SURVEY INSTRUMENT

In order to determine what impact, if any, we are having, and to learn about the factors that are associated with career choices, we would like you to answer the following questions. Your individual responses will be kept confidential.

1. Are you involved in the Earth and Mineral Science (EMS) program or the Eberly College of Science (ECoS) program? (Circle the answer) ___EMS_________ECoS________

2. What is your date of birth?
________ / ________ / ________
Month Day Year

3. In which city were you born? _________________________________

4. What gender are you?
Male ❑
Female ❑

5. When will you graduate from high school?
________ / ________
Month Year

6. Is this your first EMS or ECoS-sponsored experience?
Yes ❑
No ❑

7. Which of the following describes you best? (Check all that apply.)

African-American	❑
Hispanic or Latino	❑
Native American	❑
Pacific Islander (Guamanian, Samoan, etc.)	❑
Asian	❑
White (non-Hispanic or Latino)	❑
Other: (Please specify)	

8. How likely are you to major in each of the following subjects at college?

	Will definitely major	Will probably major	May or may NOT major	Will probably NOT major	Will definitely NOT major
a. Astronomy	❑	❑	❑	❑	❑
b. Biology	❑	❑	❑	❑	❑
c. Business	❑	❑	❑	❑	❑
d. Chemistry	❑	❑	❑	❑	❑
e. Computer Science	❑	❑	❑	❑	❑
f. Education	❑	❑	❑	❑	❑
g. Engineering	❑	❑	❑	❑	❑
h. Fine Arts	❑	❑	❑	❑	❑
i. Geosciences	❑	❑	❑	❑	❑
j. Liberal Arts	❑	❑	❑	❑	❑
k. Materials Science	❑	❑	❑	❑	❑
l. Mathematics	❑	❑	❑	❑	❑
m. Physics	❑	❑	❑	❑	❑
n. Statistics	❑	❑	❑	❑	❑
o. Other (*please specify*) ..... ____________________	❑	❑	❑	❑	❑

9. Please indicate which of the following classes you have taken or will take in high school.

	Have taken	Will take	Laboratory included?
a. Astronomy	____	____	____
b. Biology	____	____	____
c. Chemistry	____	____	____
d. Computer Science	____	____	____
e. Earth Science	____	____	____
f. Physics	____	____	____
g. Calculus	____	____	____
h. Statistics	____	____	____
i. Other science	____	____	____

10. How much do you enjoy outside activities, such as bicycling, camping, fishing, or hiking?

I like these activities a lot .... ❑
I like these activities .... ❑
I neither like nor dislike these activities .... ❑
I dislike these activities...................................... ❑
I dislike these activities a lot.............................. ❑

11. In the past 12 months, about how often did you participate in outside activities, such as bicycling, camping, fishing, or hiking?

At least once a week .... ❑
2 - 3 times a month .... ❑
About once a month... ❑
Less than 6 times in the last year .... ❑
Never ❑

12. How much do you agree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. People should be more concerned about nature and the environment.	❑	❑	❑	❑	-
b. I enjoy observing nature.	❑	❑	❑	❑	-
c. I enjoy reading nature books and magazines.	❑	❑	❑	❑	-
d. I enjoy watching television shows about nature and scientific phenomena.	❑	❑	❑	❑	-
e. I enjoy traveling to different places.	❑	❑	❑	❑	-
f. I would rather work on a science project in an outdoor setting than in a research laboratory.	❑	❑	❑	❑	-
g. I find science subjects interesting.	❑	❑	❑	❑	
h. If I want to, I can become a scientist, mathematician, or an engineer.	❑	❑	❑	❑	❑

13. How much do you agree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. I know enough English, Science, and Math to do well in college.	❑	❑	❑	❑	❑
b. I have the study skills to do well in college.	❑	❑	❑	❑	❑
c. To be successful, it is important to have a college degree.	❑	❑	❑	❑	❑
d. I am worried about being able to pay for a college education.	❑	❑	❑	❑	❑
e. I can see myself or others like me as a scientist.	❑	❑	❑	❑	❑
f. Science is difficult for me.	❑	❑	❑	❑	❑
g. Scientists work together as a team.	❑	❑	❑	❑	❑
h. Doing science is isolating.	❑	❑	❑	❑	❑
i. Science research requires coordinating results from multiple studies.	❑	❑	❑	❑	❑
j. My high school experiences with science have been primarily through worksheets.	❑	❑	❑	❑	❑
k. My high school experiences with science have been primarily through a hands-on approach.	❑	❑	❑	❑	❑
l. I have had an enjoyable high school science experience.[3]	❑	❑	❑	❑	❑

14. How much do you know about the college application process?

I know a great deal... ❑
I have a general idea of the application process .... ❑
I know very little about applying to college .... ❑
I know almost nothing about applying to college.................................... ❑

15. How much do you know about each of the following?

	I know a great deal	I know a moderate amount	I know a few things	I know very little	I know nothing
a. The SAT.	❑	❑	❑	❑	❑
b. Scholarships that are available to help pay for college.	❑	❑	❑	❑	❑
c. Other ways to help pay for college.	❑	❑	❑	❑	❑

[3] Items e-l added to the survey by the primary researcher.

d. Government programs to help pay for college.	❑	❑	❑	❑	❑

16. Which of the following best describes your feelings about working in study groups or teams?

I always prefer to work in study groups or teams…………….….....	❑
I usually prefer to work in study groups or teams…………….….....	❑
I sometimes prefer to work in study groups or teams…………...	❑
I rarely prefer to work in study groups or teams………………...	❑
I never prefer to work in study groups or teams………………...	❑

17. How much do you agree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree
a. I know what astronomers do at work.	❑	❑	❑	❑
b. I know what biologists do at work.	❑	❑	❑	❑
c. I know what chemists do at work.	❑	❑	❑	❑
d. I know what computer scientists do at work.	❑	❑	❑	❑
e. I know what engineers do at work.	❑	❑	❑	❑
f. I know what forensic scientists do at work.	❑	❑	❑	❑
g. I know what geologists and geoscientists do at work.	❑	❑	❑	❑
h. I know what mathematicians do at work.	❑	❑	❑	❑
i. I know what physicists do at work.	❑	❑	❑	❑
j. I know what statisticians do at work.	❑	❑	❑	❑
k. Astronomers are well paid.	❑	❑	❑	❑
l. Biologists are well paid.	❑	❑	❑	❑
m. Chemists are well paid.	❑	❑	❑	❑
n. Computer scientists are well paid.	❑	❑	❑	❑
o. Engineers are well paid.	❑	❑	❑	❑
p. Forensic scientists are well paid.	❑	❑	❑	❑
q. Geoscientists are well paid.	❑	❑	❑	❑
r. Mathematicians are well paid.	❑	❑	❑	❑
s. Physicists are well paid.	❑	❑	❑	❑
t. Statisticians are well paid.	❑	❑	❑	❑

18. How much do you agree with each of the following statements about your career plans?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. I want a career that allows me to work mostly in my home community after I graduate.	❑	❑	❑	❑	❑

b. I want a career that allows me to travel to different U.S. locations and perhaps different countries for work.	❑	❑	❑	❑	❑

19. How much do you agree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. My family would be very supportive if I decided to major in a science field.	❑	❑	❑	❑	❑
b. My friends would be very supportive if I decided to major in a science field.	❑	❑	❑	❑	❑

20. How much do you agree with each of the following?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. There is a real sense of community among EMS/ECoS students and faculty.	❑	❑	❑	❑	❑
b. EMS/ECoS faculty members are easy to talk with.	❑	❑	❑	❑	❑
c. EMS/ECoS faculty members are willing to answer questions outside of class.	❑	❑	❑	❑	❑
d. EMS/ECoS faculty members make their subject interesting.	❑	❑	❑	❑	❑

21. Please check one box on each line to indicate the extent to which you agree with the following statements about the College of Earth and Mineral Sciences (EMS) and the Eberly College of Science (ECoS).

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't know
a. EMS/ECoS is interesting.	❑	❑	❑	❑	❑
b. EMS/ECoS is fun.	❑	❑	❑	❑	❑
c. EMS/ECoS is important.	❑	❑	❑	❑	❑
d. EMS/ECoS is hard.	❑	❑	❑	❑	❑
e. EMS/ECoS is useful.	❑	❑	❑	❑	❑
f. I could get a job in an EMS/ECoS field.	❑	❑	❑	❑	❑

22. How interested are you in each of the following science topics?

	Very interested	Interested	Slightly interested	Not interested	Don't Know
a. Astronomy & Astrophysics	❑	❑	❑	❑	❑

	Very interested	Interested	Slightly interested	Not interested	Don't Know
b. Biochemistry and Molecular Biology	❑	❑	❑	❑	❑
c. Biology	❑	❑	❑	❑	❑
d. Chemistry	❑	❑	❑	❑	❑
e. Forensic Science	❑	❑	❑	❑	❑
f. Mathematics	❑	❑	❑	❑	❑
g. Physics	❑	❑	❑	❑	❑
h. Statistics	❑	❑	❑	❑	❑
i. Materials Science (ceramics, polymers)	❑	❑	❑	❑	❑
j. Meteorology / Atmospheric Science	❑	❑	❑	❑	❑
k. Geography / Global Info. Systems	❑	❑	❑	❑	❑
l. Geoscience / Earth Science	❑	❑	❑	❑	❑
m. Petroleum / Natural Gas / Mining	❑	❑	❑	❑	❑
n. Hydrology	❑	❑	❑	❑	❑
o. Industrial Health & Safety	❑	❑	❑	❑	❑
p. Environmental Engineering	❑	❑	❑	❑	❑
q. International Resource Management	❑	❑	❑	❑	❑
r. Climate Change	❑	❑	❑	❑	❑
s. Energy, Business and Finance	❑	❑	❑	❑	❑

Thank you for completing this survey!

Appendix J

SEEMS POST SURVEY INSTRUMENT

In order to determine what impact, if any, we are having, and to learn about the factors that are associated with career choices, we would like you to answer the following questions. Your individual responses will be kept confidential.

1. Are you involved in the Earth and Mineral Science (EMS) program or the Eberly College of Science (ECoS) program? (Circle the answer) ___EMS_________ECoS________

2. What is your date of birth?
________ / ________ / ________
Month Day Year

3. In which city were you born? _________________________________

4. What gender are you?
Male ❑
Female ❑

5. When will you graduate from high school?
________ / ________
Month Year

6. Is this your first EMS or ECoS-sponsored experience?
Yes ❑
No ❑

7. Which of the following describes you best? (Check all that apply.)

African-American	❑
Hispanic or Latino	❑
Native American	❑
Pacific Islander (Guamanian, Samoan, etc.)	❑
Asian	❑
White (non-Hispanic or Latino)	❑
Other: (Please specify)	

8. How likely are you to major in each of the following subjects at college?

	Will definitely major	Will probably major	May or may NOT major	Will probably NOT major	Will definitely NOT major
a. Astronomy	❑	❑	❑	❑	❑
b. Biology	❑	❑	❑	❑	❑
c. Business	❑	❑	❑	❑	❑
d. Chemistry	❑	❑	❑	❑	❑
e. Computer Science	❑	❑	❑	❑	❑
f. Education	❑	❑	❑	❑	❑
g. Engineering	❑	❑	❑	❑	❑
h. Fine Arts	❑	❑	❑	❑	❑
i. Geosciences	❑	❑	❑	❑	❑
j. Liberal Arts	❑	❑	❑	❑	❑
k. Materials Science	❑	❑	❑	❑	❑
l. Mathematics	❑	❑	❑	❑	❑
m. Physics	❑	❑	❑	❑	❑
n. Statistics	❑	❑	❑	❑	❑
o. Other (*please specify*) ____________________	❑	❑	❑	❑	❑

9. Please indicate which of the following classes you have taken or will take in high school.

	Have taken	Will take	Laboratory included?
a. Astronomy	____	____	____
b. Biology	____	____	____
c. Chemistry	____	____	____
d. Computer Science	____	____	____
e. Earth Science	____	____	____
f. Physics	____	____	____
g. Calculus	____	____	____
h. Statistics	____	____	____
i. Other science	____	____	____

10. How much do you enjoy outside activities, such as bicycling, camping, fishing, or hiking?

I like these activities a lot .... ❑
I like these activities .... ❑
I neither like nor dislike these activities .... ❑
I dislike these activities...................................... ❑
I dislike these activities a lot.............................. ❑

11. In the past 12 months, about how often did you participate in outside activities, such as bicycling, camping, fishing, or hiking?

At least once a week .... ❑
2 - 3 times a month .... ❑
About once a month... ❑
Less than 6 times in the last year .... ❑
Never ❑

12. How much do you agree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. People should be more concerned about nature and the environment.	❑	❑	❑	❑	
b. I enjoy observing nature.	❑	❑	❑	❑	
c. I enjoy reading nature books and magazines.	❑	❑	❑	❑	
d. I enjoy watching television shows about nature and scientific phenomena.	❑	❑	❑	❑	
e. I enjoy traveling to different places.	❑	❑	❑	❑	
f. I would rather work on a science project in an outdoor setting than in a research laboratory.	❑	❑	❑	❑	
g. I find science subjects interesting.	❑	❑	❑	❑	
h. If I want to, I can become a scientist, mathematician, or an engineer.	❑	❑	❑	❑	❑
i. This program has increased my interest in becoming a scientist.	❑	❑	❑	❑	

13. How much do you agree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. I know enough English, Science, and Math to do well in college.	❑	❑	❑	❑	❑
b. I have the study skills to do well in college.	❑	❑	❑	❑	❑
c. To be successful, it is important to have a college degree.	❑	❑	❑	❑	❑
d. I am worried about being able to pay for a college education.	❑	❑	❑	❑	❑

14. How much do you know about the college application process?

I know a great deal... ❑
I have a general idea of the application process .... ❑
I know very little about applying to college .... ❑
I know almost nothing about applying to college................................... ❑

15. How much do you know about each of the following?

	I know a great deal	I know a moderate amount	I know a few things	I know very little	I know nothing
a. The SAT.	❑	❑	❑	❑	❑
b. Scholarships that are available to help pay for college.	❑	❑	❑	❑	❑
c. Other ways to help pay for college.	❑	❑	❑	❑	❑
d. Government programs to help pay for college.	❑	❑	❑	❑	❑

16. Which of the following best describes your feelings about working in study groups or teams?

I always prefer to work in study groups or teams……………….... ❑
I usually prefer to work in study groups or teams……………….... ❑
I sometimes prefer to work in study groups or teams………….... ❑
I rarely prefer to work in study groups or teams………………... ❑
I never prefer to work in study groups or teams…………………... ❑

17. How much do you agree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree
a. I know what astronomers do at work.	❑	❑	❑	❑
b. I know what biologists do at work.	❑	❑	❑	❑
c. I know what chemists do at work.	❑	❑	❑	❑
d. I know what computer scientists do at work.	❑	❑	❑	❑
e. I know what engineers do at work.	❑	❑	❑	❑
f. I know what forensic scientists do at work.	❑	❑	❑	❑
g. I know what geologists and geoscientists do at work.	❑	❑	❑	❑
h. I know what mathematicians do at work.	❑	❑	❑	❑
i. I know what physicists do at work.	❑	❑	❑	❑
j. I know what statisticians do at work.	❑	❑	❑	❑
k. Astronomers are well paid.	❑	❑	❑	❑
l. Biologists are well paid.	❑	❑	❑	❑
m. Chemists are well paid.	❑	❑	❑	❑
n. Computer scientists are well paid.	❑	❑	❑	❑
o. Engineers are well paid.	❑	❑	❑	❑
p. Forensic scientists are well paid.	❑	❑	❑	❑
q. Geoscientists are well paid.	❑	❑	❑	❑
r. Mathematicians are well paid.	❑	❑	❑	❑
s. Physicists are well paid.	❑	❑	❑	❑
t. Statisticians are well paid.	❑	❑	❑	❑

18. How much do you agree with each of the following statements about your career plans?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. I want a career that allows me to work mostly in my home community after I graduate.	❑	❑	❑	❑	❑
b. I want a career that allows me to travel to different U.S. locations and perhaps different countries for work.	❑	❑	❑	❑	❑

19. How much do you agree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. My family would be very supportive if I decided to major in a science field.	❑	❑	❑	❑	❑
b. My friends would be very supportive if I decided to major in a science field.	❑	❑	❑	❑	❑

20. How much do you agree with each of the following?

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. There is a real sense of community among the EMS/ECoS students and faculty.	❑	❑	❑	❑	❑
b. EMS/ECoS faculty members are easy to talk with.	❑	❑	❑	❑	❑
c. EMS/ECoS faculty members are willing to answer questions outside of class.	❑	❑	❑	❑	❑
d. EMS/ECoS faculty members make their subject interesting.	❑	❑	❑	❑	❑

21. Please check one box on each line to indicate the extent to which you agree with the following statements about the College of Earth and Mineral Sciences (EMS) and the Eberly College of Science (ECoS).

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't know
a. EMS/ECoS is interesting.	❑	❑	❑	❑	❑
b. EMS/ECoS is fun.	❑	❑	❑	❑	❑
c. EMS/ECoS is important.	❑	❑	❑	❑	❑
d. EMS/ECoS is hard.	❑	❑	❑	❑	❑
e. EMS/ECoS is useful.	❑	❑	❑	❑	❑
f. I could get a job in an EMS/ECoS field.	❑	❑	❑	❑	❑

22. How interested are you in each of the following science topics?

	Very interested	Interested	Slightly interested	Not interested	Don't Know
a. Astronomy & Astrophysics	❑	❑	❑	❑	❑
b. Biochemistry and Molecular Biology	❑	❑	❑	❑	❑
c. Biology	❑	❑	❑	❑	❑
d. Chemistry	❑	❑	❑	❑	❑

	Very interested	Interested	Slightly interested	Not interested	Don't Know
e. Forensic Science	❑	❑	❑	❑	❑
f. Mathematics	❑	❑	❑	❑	❑
g. Physics	❑	❑	❑	❑	❑
h. Statistics	❑	❑	❑	❑	❑
i. Materials Science (ceramics, polymers)	❑	❑	❑	❑	❑
j. Meteorology / Atmospheric Science	❑	❑	❑	❑	❑
k. Geography / Global Info. Systems	❑	❑	❑	❑	❑
l. Geoscience / Earth Science	❑	❑	❑	❑	❑
m. Petroleum / Natural Gas / Mining	❑	❑	❑	❑	❑
n. Hydrology	❑	❑	❑	❑	❑
o. Industrial Health & Safety	❑	❑	❑	❑	❑
p. Environmental Engineering	❑	❑	❑	❑	❑
q. International Resource Management	❑	❑	❑	❑	❑
r. Climate Change	❑	❑	❑	❑	❑
s. Energy, Business and Finance	❑	❑	❑	❑	❑

23. Please check one box on each line to indicate the extent to which you agree with the following statements about the program you have just completed.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't know
a. This program significantly increased my knowledge of EMS/ECoS.	❑	❑	❑	❑	❑
b. This program increased my knowledge of careers in EMS/ECoS.	❑	❑	❑	❑	❑
c. This program increased my interest in EMS/ECoS.	❑	❑	❑	❑	❑

24. Would you like an internship next summer in an area covered by the EMS/ECoS experience?

Yes ❑

No ❑

Don't know ❑

Thank you for completing this survey!

Appendix K

FIRST ROUND CODING SCHEME

Categories **Grouping Similar Codes**	**Code Name** **Criteria or Components of Construct**	**Definition** **Data to Provide Evidence of Criteria Being Present**
Conceptual Understanding	Making sense of the problem	Generating questions to clarify points related to the project
Practice of Science	Collecting data	Making intelligible decisions on what data is appropriate for their project
Practice of Science	Constructing explanations	Making assertions based upon the data collected.
Practice of Science	Using inscriptions	Applying the use of cultural expressions of science relative to Satellite Meteorology appropriately.
Practice of Science	Using instruments	Using scientific instruments relevant to the cultural practices of Satellite Meteorology to engage in the science research experience
Practice of Science	applying reasoning	Using inductive and deductive reasoning to ascertain how/what the findings are.
Practice of Science	recognizing patterns in the data	Identify relevant patterns in the data
Practice of Science	Identifying the problem	Use of language to articulate research objectives
Conceptual Understanding	Making connections to the real world	Using real world examples to better explain a concept or idea
Introduction	Providing background information	Presentation of background information on key concepts related to the research project. Defining goals and objectives of the project.
Practice of Science	Publishing	Organizing data/results to be presented
Introduction	Questioning background information	Questions posed by students about background information
Introduction	Defining terminology	
	Addressing limitations	Explanation of limitations associated with using instruments
	Providing theoretical information	Addressing the theoretical background/formulas

Instruction	Reinforcing and Preparing	Suggested homework
	Introduction to the Problem	
Conceptual Understanding	Providing Explanations	Clarifying information using illustrations or visual aids.
	Introducing instruments	Providing background information on the instruments used

Appendix L

2007 SEEMS SATILLTE METOEROLOGY CURRICULUM DESIGN

OUTLINE (BY WEEK)

Week 1 - Hands-on introduction to MODIS (MODERATE-RESOLUTION IMAGING SPECTRORADIOMETER) weather satellite imagery. Examine typical MODIS images of weather, exploring cloud types and landscapes. Look for similarity in patterns between images. Learn to distinguish clouds from snow. - June 19 (1.5 hours) and June 21 - <faculty mentor> leads

Week 2 - Learn to use Google Earth to obtain terrain height, latitude and longitude. Apply photogrammetric image analysis and inductive reasoning to understand the role of topography in cumulus cloud formation. - June 26 and 28 - <faculty mentor> leads

Week 3 - Learn to use cloud shadow photogrammetry to determine cloud height from satellite images. Calculate the cloud height as a function of location, terrain, and cloud size. - July 3 and 5 - <faculty mentor> leads

Week 4 - Finish calculating the cloud height as a function of location, terrain, and cloud size. Determine the statistical relationships between cloud characteristics and terrain. - July 10 and 12 - <faculty mentor> leads

Week 5 - Finish determining the relationships between terrain and cloud formation. Use deductive reasoning to determine why clouds form when and where they do. - July 17 and July 19 - Fisher leads

Week 6 - This week will be used to catch up if need be and then plan, prepare, and polish the presentation. - July 24 and 26 - <faculty mentor> leads

STUDENT RESEARCH TASKS

Note: This section expands on the project outline above, providing details of what the students will accomplish in each period

A. **Week 1 - Hands-on introduction to MODIS weather satellite imagery.**
Period 1 - June 19
   i. EMS Introductions - 90 minutes
   ii. Trek to Room 620 Walker Building - 15 minutes
   iii. Introduction to the project - 60 minutes
      a. Discussion of project objectives
      b. Discuss our goal: to discover the effect of terrain on cumulus cloud formation and deduce the reasons for this behavior
      c. Explore the existing theory relating cumulus formation to terrain patterns - Use links on background web page
      d. Work together at one multi-display computer
      e. Students should explore the meteorology web sites at depth before the next meeting.
   iv. Introduction to image viewing - 15 minutes
      a. Loading MODIS satellite images
      b. Navigating images

1. Pan
2. Zoom

Period 2 - June 21

v. Lead a student discussion of the phenomena visible in the images - 180 minutes - Images stored on local PCs and the web
   a. Use Firefox to show MODIS satellite images
   b. Talk about the MODIS satellites and how they obtain these images - Use links on background web page
   c. Learn to distinguish clouds from snow.
   d. Look for similarity in patterns between images.
   e. Work together at one multi-display computer
   f. Make sure students discover multiple cloud types including those formed by terrain-modified flow fields

B. Week 2 - Hands-on exploration of weather and topographic imagery

Period 1 -June 26

i. Learn to use Google Earth to obtain terrain height, latitude and longitude. - 60 minutes
ii. Determine the location and latitude of prominent mountains, basins, and lakes. - 120 minutes
   a. Work together at one multi-display computer

Period 2 - June 28

iii. Apply photogrametric image analysis and inductive reasoning to understand the role of topography in cumulus cloud formation. - 180 minutes
   a. Work together at one multi-display computer

C. Week 3 - Quantitative analysis of weather and topographic imagery

Period 1 - July 3

i. Learn to use cloud shadow photogrammetry to determine cloud height from satellite images. - Use links on background web page - Images stored on local PCs and the web - 180 minutes
   a. Work together at one multi-display computer
   b. Take copious notes
ii. Calculate the cloud height as a function of location, terrain, and cloud size. - Images stored on local PCs and the web - 180 minutes
   a. Work in two teams of two, each team with their own computer
   b. Take copious notes

Period 2 - July 5

iii. Continue the quantitative analysis begun in period 1. - 180 minute

D. Week 4 - Statistical analysis of quantitative data

Period 1 - July 10

i. Finish calculating the cloud height as a function of location, terrain, and cloud size. - 60 minutes
ii. Use Excel™ to find the statistical relationship between cumulus characteristics and terrain
   a. Plotting in Excel™ - 60 minutes
   b. Doing statistics in Excel™ - 30 minutes
   c. What questions to ask via statistics -30 minutes

Period 2 - July 12

iii. What statistics to use? - Correlation, Regression, T-test - 60 minutes
iv. Determine the statistical relationships between cloud characteristics and terrain. - 120 minutes
    a. Students work in one group

E. **Week 5 - Explain the relationships between terrain and cloud formation.**

Period 1 - July 17

i. Finish determining the relationship between cloud formation and terrain - 60 minutes
ii. Use deductive reasoning to determine why clouds form they do.
    a. Why is the favored time of day best? - 30 minutes
    b. Why are the favored terrain patterns best? - 90 minutes

Period 2 - July 19

iii. Determine which results to present - 60 minutes
iv. Results Presentation - 60 minutes
    a. Show and discuss the universal outline for a presentation
    b. Introduction to whatever software tool the students need for preparing their results presentation
v. Students work as one large group preparing a group report on their findings - 60 minutes

F. **Week 6 - July 24 and 26**

i. Reserve week that will be used to catch up and to polish results for presentation - 2 periods are available - coordinate ahead of time with SEEMS management about presentation formats and tools. - 360 minutes

Appendix M

2007 SEEMS SATELLITE METEROLOGY RESEARCH GROUPS

2007 SEEMS Research Experience	Objective
Climate Change in Africa	The participants in this summer experience will receive an introduction to climate change and will learn why nations in Africa are particularly vulnerable. We will also develop a climate change research project where participants will access various government and university climate data sets or selected regions in Africa, and will examine future climate projections in the context of current trends.
Forensic Ice Age Vertebrate Paleoecology	This project is part of on-going research in the biogeography and paleoecology of Ice Age vertebrates from caves in the Black Hills of SD. Students will examine the biases in fossil samples in order to determine their validity in making paleoenvironmental reconstructions.
Interpretation of Field Observations Collected at Ancient Archaeological Sites in Southern Egypt	The objective is to interpret a subset of a large body of field observations made during the past several years at the ancient Temple-Town site, Hierakonpolis, in southern Egypt to better understand the current shallow groundwater conditions that threaten buried structures and artifacts within the Temple-Town’s walled perimeter.
Molluscan body size changes following the Cretaceous mass extinction and during episodes of global warming	Students will participate in a hands-on research experience that is focused on discovering how the body size of mollusks (clams and snails) changed during twenty million years of evolution. Participants will learn about ancient life, how organisms become fossils, and the processes of evolution and extinction.
Petroleum Engineering	Production engineering is the branch of petroleum and natural gas engineering that deals with the extraction of hydrocarbon fluids and their treatment and handling at the surface. Petroleum engineers are employed by multinational petroleum companies for the exploration, development and extraction of underground hydrocarbon deposits. The petroleum and natural gas engineer working in production operations must utilize laboratory data for the quantitative evaluation of reservoir fluid production and for the design and development of processes and equipment to optimize oil and gas production. In this summer experience, the participant will be introduced to the basic concepts of petroleum production and will be exposed to a hands-on laboratory experience about the principles and procedures utilized for oil and gas analysis and fluid flow. The participant will learn how petroleum fluid properties, such as density, API, viscosity, heat of combustion, BS&W, water vapor content, and composition, are measured in the laboratory.

Petroleum Production Engineering	Students participating in this summer research experience will conduct hands-on laboratory tests that are fundamental to petroleum engineering, the estimation of oil reserves, and the extraction of hydrocarbons from underground reservoirs. Students participating in this research activity will measure important rock and fluid properties and will be guided through the interpretation of those properties and their application to petroleum engineering problems.
Polymers and Materials Science	Our SEEMS project introduces the students to the basic scientific methods behind materials science and engineering, with a focus on polymers. We learn the basics of polymer science - what polymers are, how they are made, and why they have the properties that make them special. The students then investigate the properties of some rubber compounds made from a commercial silicone polymer blended with various inorganic additives- including carbon black, cloisite (a clay), and fumed silica. Students fabricate rubber "super balls" using a simple molding process. Balls are then bounce-tested to investigate which additives have the greatest effect on the properties of the rubber. At the end of the experience, students prepare a presentation summarizing their findings and showing how they applied the scientific method to choose the best material for the job.
Satellite Meteorology	This project focuses on the use of weather satellite images to determine the height for the fair weather cumulus clouds over the Tibetan plateau. This research is motivated by the long-standing goal of collaborator Dr. <research pilot’s name> <University Researcher works for>t o be the first person to fly a glider over Mount Everest.
Summer Research Experience on the Basics of Thermodynamics, Phase Transformations and Diffusion	In the present workshop, students will be first introduced to the basics of thermodynamics, following which they will be asked to perform a diffusion couple experiment, thus getting acquainted with the laboratory atmosphere. The experimental research work includes analysis of samples using an optical microscope and SEM, identifying phases and their compositions. The current research experience will help students understand the basic concepts of phase transformations and diffusion, and gain hands-on experience with some of the very advanced characterization techniques, which will further enable them to obtain a strong foundation as they step into a professional life.

Why ozone pollution is worse on hot days?	Our project examines the summertime air quality and ozone pollution in Houston, Texas, using air chemistry data taken in summer 2006. In urban areas, human activities are considered a major cause of air pollution — both ozone and small particles. The pollution is worse in cities on hot, sunny, summer days because of high reactivity of air pollutants. By analyzing these data, the students can answer the question: Why ozone pollution is worse on hot days, especially in big cities like Houston, Texas?

Appendix N

TRIO Programs

Year Founded	Program Name	Program Description[4]
1964	Upward Bound	Upward Bound provides fundamental support to participants in their preparation for college entrance. The program provides opportunities for participants to succeed in their precollege performance and ultimately in their higher education pursuits. Upward Bound serves: high school students from low-income families; high school students from families in which neither parent holds a bachelor's degree; and low-income, first-generation military veterans who are preparing to enter postsecondary education. The goal of Upward Bound is to increase the rate at which participants complete secondary education and enroll in and graduate from institutions of postsecondary education.
1965	Talent Search	This program identifies and assists individuals from disadvantaged backgrounds who have the potential to succeed in higher education. The program provides academic, career, and financial counseling to its participants and encourages them to graduate from high school and continue on to the postsecondary institution of their choice. Talent Search also serves high school dropouts by encouraging them to reenter the education system and complete their education. The goal of Talent Search is to increase the number of youths from disadvantaged backgrounds who complete high school and enroll in postsecondary education institutions of their choice.
1972	Educational Opportunity Centers Program also known as Special Services for Disadvantaged Students	The Educational Opportunity Centers program provides counseling and information on college admissions to qualified adults who want to enter or continue a program of postsecondary education. An important objective of the program is to counsel participants on financial aid options and to assist in the application process. The goal of the EOC program is to increase the number of adult participants who enroll in postsecondary education institutions.
1976	Training Program for Federal TRIO Programs also known as Training Program for Special Programs Staff and Leadership Personnel	The Training Program for Federal TRIO Programs provides funding to enhance the skills and expertise of project directors and staff employed in the federal TRIO programs. Funds may be used for conferences, seminars, internships, workshops, or the publication of manuals. Training topics are based on priorities established by the secretary of education and announced in Federal Register notices inviting applications.

[4] (**U.S. Department of Education: Office of Post Secondary Education, 2007b)**

1986	Ronald E. McNair Postbaccalaureate Achievement Program	This program prepares participants for doctoral studies through involvement in research and other scholarlyactivities. Participants are from disadvantaged backgrounds and have demonstrated strong academic potential.Institutions work closely with participants as they complete their undergraduate requirements. Institutionsencourage participants to enroll in graduate programs and then track their progress through to the successfulcompletion of advanced degrees. The goal is to increase the attainment of Ph.D. degrees by students fromunderrepresented segments of society.
1990	Upward Bound Math-Science	The Upward Bound Math-Science program allows the Department to fund specialized Upward Bound math and science centers. The program is designed to strengthen the math and science skills of participating students. The goal of the program is to help students recognize and develop their potential to excel in math and science and to encourage them to pursue postsecondary degrees in math and science.
1998	TRIO Dissemination Partnership Program	This program provided grants to enable TRIO grantees to work with other institutions and agencies serving low-income and first-generation college students but that did not have TRIO grants. The goal of the TRIO Dissemination Partnership Program was to increase the effectiveness of the TRIO programs, through the replication and adaptation of successful TRIO program components, practices, strategies, and activities at institutions and agencies that do not have a federally funded TRIO project.
2001	Student Support Services	The program provides opportunities for academic development, assists students with basic college requirements, and serves to motivate students toward the successful completion of their postsecondary education. Student Support Services (SSS) projects also may provide grant aid to current SSS participants who are receiving Federal Pell Grants (# 84.063). The goal of SSS is to increase the college retention and graduation rates of its participants and help students make the transition from one level of higher education to the next.

VITA

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EDUCATION

The Pennsylvania State University State College, Pennsylvania
Doctor of Philosophy, August 2009

Xavier University of Louisiana New Orleans, Louisiana
Master of Arts *with* Honors, May 2003

Xavier University of Louisiana New Orleans, Louisiana
Bachelor of Science: Biology, May 1999

PROFESSIONAL EXPERIENCE/RESEARCH

2008	**Science Education,** *Reviewer*
2006-2008	**The Pennsylvania State University,** *Science Education Lab Coordinator*
2003-Fall 2006	**The Pennsylvania State University**, *495C Field Instructor*
2003-2004	**The Pennsylvania State University,** *Graduate Assistant:* Science Methods
1999- 2003	**Xavier University Preparatory School**, *Instructor*

PRESENTATIONS

2009 **The National Association Research in Science Teaching (NARST)**
Paper Presentation Title: Investigating the Influence of An Authentic Science Experience on Minority Student Interest in Science

2005 **Xavier University Preparatory School Career Day**
Talk Title: The Success of Minorities in Beyond High School

The Africa Interdisciplinary 2005 Spring Brown Bag Series
The Pennsylvania State University
Presentation Title: Multiculturalism in Science Education

CERTIFICATIONS

Louisiana Certified in Biology & General Science
Louisiana INTECH K-6 Certificate