WARNER, JENNIFER M., Ph.D. Supplemental Instruction for Non-Science Majors Biology Students: Meanings and Influences on Science Identities for Women. (2008) Directed by Dr. Heidi Carlone. 215 pp.

The purpose of this study was to examine the meanings women make of their participation in a Supplemental Instruction (SI) program associated with a postsecondary non-majors biology course. Interview and survey data were utilized to determine why women attended SI, the affordances provided by regular SI participation, how women depicted the learning environment of SI, and how women described science as they experienced it in SI. Additional interviews were conducted with a sub-population of participants who regularly utilized SI to provide an understanding of the role SI participation played in terms of access to science identities for women who changed their majors, minors, or concentration within an education major to biology as a result of their experiences in non-majors biology and SI.

The results of this study suggest that the SI experience provides more than just a means to increase grades for women who participate regularly. The supportive and safe climate of the SI environment set a comfort level for women that increased their competence and confidence in biology. The SI experience increased interest in biology and afforded the opportunity for women to be recognized by others, and to recognize themselves, for their science abilities. Additionally, for a small number of women, their experiences in non-majors biology and SI facilitated a shift in science identities that led the women to immigrate into science.

SUPPLEMENTAL INSTRUCTION FOR NON-SCIENCE MAJORS BIOLOGY STUDENTS: MEANINGS AND INFLUENCES ON SCIENCE IDENTITIES FOR WOMEN

by

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Approved by

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Committee Chair

This work is dedicated to my parents, Anna and Richard Warner, who have been a constant source of love and support throughout my academic career.

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION TO THE STUDY

In the American Association for the Advancement of Science's (AAAS) *Science for All Americans* (1990), "science literacy" is promoted as a top priority for high school graduates. Science literacy is defined loosely by Project 2061 as "emphasizing the connections among ideas in the natural and social sciences, mathematics, and technology" which ultimately helps individuals to understand contemporary issues in science. Postsecondary institutions have been charged to develop a curriculum that surpasses that of the science literacy goals of high school graduates. Science classes at the undergraduate level have a particularly difficult task since research has shown that many college freshman and sophomores have not yet met the stated goals for high school science literacy (Roseman & Koppal, 2006). According to one source, only 7% of all adults and 22% of college graduates have achieved science literacy (Miller, 1998). This staggering statistic provides strong evidence as to why science education reform is so very critical at all levels of education.

At the postsecondary level, whether majoring in science or not, students will be required to take courses in the sciences to fulfill institutional degree requirements. Several studies have shown that students arrive to their college classes somewhat less than prepared and retaining some major misconceptions about science (Berkheimer, Anderson, & Spees, 1990; Moffat, 1994; Roseman & Koppal, 2006). Given that science is an increasingly marginalized subject in early grades due to increased emphasis on high stakes testing in areas such as math and literacy (Jones, Jones, & Hargrove, 2003), this lack of preparedness is not a big surprise. For students, the lack of preparedness alleged by some is often coupled with negative attitudes about science that become particularly conspicuous in non-science majors courses. Given that a reported 47% of students are undeclared majors at typical large state universities (Tobias, 1992b), it is obvious that the non-majors population is large and worthy of investigation.

There are no shortages of critiques and prescriptive ideas for how to reform science education at the elementary, middle, and high school levels. At the postsecondary level, similar types of critiques and suggestions exist but are often ignored by science faculty in favor of more traditional teaching approaches (Klionsky, 2004). Traditional approaches are often explained as necessary and practical for the large enrollment classes offered at many institutions that frequently enroll hundreds of students in a single section, most often in introductory classes. First, student satisfaction in these classes is typically low (French & Russell, 2006). Second, for students who are science majors, many elect to eventually leave science in favor of a non-science major in college (Seymour & Hewitt, 1997). Even more troubling is that highly qualified female students choose to leave science more frequently than their male counterparts at a rate of 50% in the biological sciences (Seymour & Hewitt, 1997), supporting the idea that gender bias is a problem in science education.

I note two relevant, major problems with collegiate science education: (a) the traditional pedagogy that pervades undergraduate science courses leads to a low level of student satisfaction and retention, and (b) women in particular are leaving science at a greater rate than men. The organization of this chapter will involve a brief presentation of these two major problems. First, I will discuss the typical structure of how we teach postsecondary science courses and present an argument for why it is not working for many students. Second, I will present a review of the gender bias in science and science education. Following, Supplemental Instruction (SI) will be offered as a potential solution to improving students' achievement, satisfaction, and retention with non-majors biology courses, particularly for women students. Finally, I will present the specific research problem and research questions addressed with this study.

The Science Education Problem

Tobias (1992b) suggests that reform at the elementary, middle, and high school levels is an uphill battle and that it is important to "target an important and so far semi-invisible population of young people: the vast majority of the 500,000 young Americans, who survive their early school science with some interest in and talent for the subject intact" (p. 1196). The population mentioned is composed of

> freshman and sophomores at college currently enrolled in their first college science courses, courses which could—unless the experience is made to be a very positive one, both intellectually and in terms of increased self-esteem—be their last. (Tobias, 1992b, p. 1196)

Viewing the problem from this perspective highlights the importance of providing a quality experience in introductory and non-majors science classes at the postsecondary level. If not done well, it seems likely that much of this population of students will be lost from science forever.

A major criticism of college science classes is that they have traditionally relied on pure lecture and do not involve student-centered pedagogy (Klionsky, 2004). The level of student satisfaction and attitudes towards science taught by traditional lecture is generally low (French & Russell, 2006). This begs the question of why exclusive use of this method persists. As compared to other disciplines, science instructors in particular seem to adhere to the tradition of this format and hesitate to make any major changes as we they to teach as we they taught (Klionsky, 2004). Three of the common rationales cited for resisting new teaching methods include a perceived lack of importance to teaching as it relates to promotion and tenure issues (Walczyk, Ramsey, & Zha, 2007), a lack of training in good pedagogy (Walczyk et al., 2007), and the limitations of class size (Klionsky, 2004). In visiting the websites of several large institutions (University of Southern California, University of North Carolina, University of Missouri, University of California Los Angeles, and Michigan State University) and reviewing information from registrar's offices, the typical enrollment for non-majors biology for the Fall 2007 semester ranged from 100 to more than 500 students per section. In class sections of this size, it is undeniable that there are many challenges that arise for both the students and the instructors. One disturbing trend is that so much of the science education reform literature directly emphasizes the importance of small class size as a function of student achievement and satisfaction, yet many colleges and universities are being forced to offer high demand or required classes by teaching them in larger and larger sections.

When considering non-science majors course design, it is important keep in mind its population and their histories with or in science. Many non-majors students report negative experiences in earlier science courses (Congos, Langsam, & Schoeps, 1997), which may be one potential explanation for their decision not to major in science. Understanding that students who chose not to major in science have had less than positive experiences with science in the past which may have biased them before they even walk into a science class on the first day of the semester, is important when designing the course. Blank and Gruebel (1993) reported that 95% of students complete a year of biology in high school, yet few students aspire to major in science, and 50% of that small group end up leaving their science major eventually, leaving only 12% of all bachelor's degrees earned in the natural sciences (National Science Board, 2004). To paint an even bleaker picture, a study by the National Research Council suggested that the teaching of high school biology is so unsatisfactory that "nothing short of a massive attack" could fix it (Committee on High School Biology, 1990). This committee also highlighted serious deficiencies in all levels of science education and stated their opinion of high school biology courses is that they are "designed to snuff out interest" of students.

In comparison to other science disciplines such as chemistry and physics, more students are exposed to biology that any other science during high school. The allegations about the quality of this experience are particularly disheartening and imply that our approach to teaching biology is not effective for sustaining an interest in science. This may explain, in part, the large audience of non-science majors found at colleges and universities and provide context for understanding the anxieties of non-science majors. The statistics are discouraging but they provide a much needed impetus for making changes in science education at all levels.

Gender Bias in Science and Science Education

The gender bias in science education is well documented. This bias is evident in elementary school when both girls and boys express interest in science, but girls have a more negative attitude about science (Andre, Whigham, Hendrickson, & Chambers, 1999). By middle school, girls perceive a difficulty associated with science and are interested in science primarily for the reason of helping others (Jones, Howe, & Rua, 2000). These differences in attitudes, perceived difficulty, and interest in science have been attributed, in part, to the differential treatment of girls through their science educations (Guzzetti & Williams, 1996; Kahle, 1996; Oakes, 1990; Tindall & Hamil, 2004; Woolfolk, 2001). Throughout high school, girls' participation and interest in science diminishes steadily (Hanson, 1996; Oakes, 1990).

The science "talent pool" has been reported to be set by grade 12, often earlier, and the only changes to the population of this talent pool are reported to be emigration from science (Berryman, 1983). For the women in this science talent pool who do elect to major in science at the postsecondary level, a disproportionate number of highly qualified women students, roughly 50%, leave science majors as compared to males (Seymour & Hewitt, 1997). A few reasons cited by the "switchers" from science majors were frustrations with the competitive nature of science, the non-supportive culture, and a perceived level of difficulty in science. Seymour and Hewitt (1997) contend that the problem is not related to a deficit of any sort in the women but is directly related to how college science courses are taught and that specific forms of pedagogy coupled with a positive classroom climate are factors likely to encourage women to continue with science.

Clearly there are problems related to the differential treatments and social expectations of women in science. Early science education experiences may explain why many women end up in the non-majors college population. Perhaps they were completely discouraged by their early science education and entered college as a declared non-major or they persisted in science at the college level and later "switched" due to problems with how science is taught at the college level. In either case, it is evident that science education at all levels bears some responsibility for the lack of women or retention of women in science. Offering support programs that are aligned with best practices in science education may be one way to increase the satisfaction of women in college science courses.

Supplemental Instruction

With enrollments in courses climbing into the hundreds per section at many universities, particularly in introductory and freshman level classes, it seems appropriate to investigate better ways to circumvent the problems typically associated with these large classes in order to increase student success and satisfaction with these courses. While there is no shortage for prescriptive ideas for how to improve college science education, the fact is that many introductory science instructors are burdened with heavy teaching loads and very large class sections. Further, some have suggested that reform efforts focused on classroom curriculum and pedagogy that search for a "magic bullet" are doomed to fail, especially without institutional support systems (Tobias, 1992a).

While making curriculum and classroom change is a laudable goal, these sorts of changes tend to be resisted by science faculty (Klionsky, 2004). However, options exist for the implementation of additional supportive changes that can be made outside the classroom. One example of such a change is the implementation of SI programs associated with large science classes. Programs such as SI have a long history of improving student performance in large classes in multiple disciplines including the sciences (Blanc, DeBuhr, & Martin, 1983; Collins, 1982; Congos et al., 1997; Congos & Schoeps, 1993; Hodges & White, 2001; Ogden, Thompson, Russell, & Simons, 2003; Shaya, Petty, & Petty, 1993; Zaritsky & Toce, 2006). They require virtually no effort on the part of the instructor to implement and maintain, yet they provide a tremendous advantage for the students who choose to take advantage of the program.

Supplemental Instruction was developed at the University of Missouri - Kansas City in 1973 with the goal of helping students in health science professional schools master course content and integrate learning and study strategies (Martin & Blanc, 1981). Later, the program was applied to undergraduate courses with high enrollments that also typically have a high D/F/W rate. The program has now been adopted by more than 1,000 colleges and universities internationally. The peer-based SI model for undergraduate courses involves three goals: to improve student grades, to reduce attrition rates, and to increase graduation rates (Center for Supplemental Instruction, 2000). The program is student-centered and includes a student leader of each SI session. The student leader is one who completed and excelled in the class in a previous semester and who has been trained in the methods of SI. Students may voluntarily participate in the SI program at any time they feel like they need the support. A typical session involves collaborative group interactions and facilitation from the SI leader to help the small peer groups clarify their concerns and construct answers to their questions.

There has been extensive analysis on the effectiveness of SI programs, and it is clear that SI makes a significant difference in course grades for many students. As an average across disciplines, students who attend SI on a regular basis make one half to one letter grade higher in the course than students who do not attend SI on a regular basis (Blanc et al., 1983; Collins, 1982; Congos et al., 1997; Congos & Schoeps, 1993; Hodges & White, 2001; Ogden et al., 2003; Shaya et al., 1993; Zaritsky & Toce, 2006). This experience for participants in SI may be the difference between a B student earning an A in the class or the difference between passing and failing for a struggling student. The benefits of regular SI participation on students' grades are clear for those who choose to participate. In addition, there is some evidence that SI may also include long-term benefits for regularly participating students. These benefits include connecting better with other students in study groups and applying their study skills learned in SI to other classes not supported with SI (Ogden et al., 2003; Price & Rust, 1995; Ramirez, 1997).

Description of the Research Problem

In the following section, I will outline gaps in the literature connected to SI and non-majors biology. First, I will discuss the problem of achievement in non-majors biology and the impact SI can have on increasing achievement for my population of regular participants. Second, I propose further examination into the meanings of SI for participants, as this is something that has not been investigated in the literature. Finally, I will propose investigating a new potential role for SI as a tool for facilitating access to science identities for a sub-population of women in non-majors biology that may lead to a long-term interest in science and pursuit of science as an academic focus.

During the past ten years I have taught more than 40 sections of non-majors biology, most of which have averaged 200 students per section. For nine of those years, I have been involved with the SI program associated with non-majors biology at my institution. While training in the SI philosophy and methods occurs through the University Center for Academic Excellence (which houses the SI program at my institution), I have recruited and facilitated the ongoing training of every SI leader in non-majors biology during this time. I have collaborated frequently with the director of the SI program at my institution and have implemented adjustments to the SI model that suit the population of non-majors biology students at my institution. The SI program for my non-majors group is one of the most well attended SI program on my campus and has served as a model to other disciplines and courses in terms of how encourage participation by students.

During any given semester, the majority of my students get help at least once in SI. Typically about 25-35% of them become “regulars” being defined as students who attend SI about once a week throughout the semester. The implementation of an SI program is one way for the students to experience biology in a personalized and non-threatening small group setting. The SI program appears to be an important part of student success in my own courses for students who are motivated to take advantage of the program. My hunch about SI’s success, backed up by literature explained in this chapter and the next, is that SI's environment and structure is particularly well aligned with what the science education literature promotes as good pedagogy for all students, and is particularly well aligned with the learning needs and preferences of women students. The data collected for my course by my institution support the notion that SI is effective in terms of increasing student achievement for my population of students (Warner, 2005).

Most of the research on SI has been purely a report on the success of attendees versus non-attendees during a given semester. Success in these studies is measured as final course grade, which is typically one half to one letter grade higher than non-attendees (Blanc et al., 1983; Collins, 1982; Congos et al., 1997; Congos & Schoeps, 1993; Hodges & White, 2001; Ogden et al., 2003; Shaya et al., 1993; Zaritsky & Toce, 2006). While this sort of research is valuable to support the academic usefulness of the program for students, there is another noted gap in the literature when it comes to understanding the meanings of SI for participants. For example, do participants view SI simply as a way to improve their grades in biology? Does their regular participation build their sense of confidence and competence in biology? What motivates the students to attend SI regularly? What do *they* find particularly beneficial about SI? Understanding the meanings and perceptions of SI for participants could have practical implications such as allowing for some changes within the design or availability of the SI program that would make it more attractive and useful to a larger audience of students.

My personal observation concerning the demographics of SI attendees over several years has revealed that participation in SI by female students far exceeds participation by male students. While my courses have a slightly skewed gender ratio (on average, 60% of my students are women), it is not nearly as dramatically skewed as the participation ratio in SI (which is always at least 80% women). In many SI sessions, the participants are all women. It has been shown that women who actively participate in SI associated with math courses tend to increase in terms of grades more so than males (Stephens, 1995). Perhaps the same advantage holds true for women students who use SI for non-majors biology courses.

In preliminary investigations of my own SI program (Warner, 2005), a third problem of interest emerged. I typically make the assumption that any student who enrolls in my class must not plan to major in the sciences since they have registered for a designated non-majors course. What has been interesting to me is that each semester I see a small number of students who seem to transform into students who are quite interested in science. They start speaking up in class, they email me articles or questions about biology-related topics, they come by to talk with me about biology, they are active participants in SI, they seem to lead their groups in lab, and they talk to other students and their friends and family about science. Eventually, some of them come to me to discuss taking more biology classes, changing their major to biology, changing their minor to biology, or if they are an education major, changing their teaching concentration to science.

I am fascinated by these transformations from decidedly "non-science" types to "science" types particularly because this goes against what has been reported in the literature (Berryman, 1983; Seymour & Hewitt, 1997; Tobias, 1992a). I decided I wanted to know more about these students, almost all of whom are females. In an earlier pilot study, I conducted in-depth interviews with women who fit the criteria of transformed science students as described above (Warner, 2007). Most of them revealed an early interest in science, but later in their academic career (usually some time in middle or high school) they began to have negative feelings towards science that persisted as they entered college. Somehow, their experiences in non-majors biology and SI sparked a renewed interest in science.

My initial perceptions after interviewing the women were, that as girls, these students displayed qualities of a developing "science identity" (Brickhouse & Potter, 2001; Brown, 2004; Brown, Reveles, & Kelly, 2005; Carlone, 2003, 2004; Carlone & Johnson, 2007; Hughes, 2001; Reveles, Cordova, & Kelly, 2004) but somehow that science identity was lost or put on hold. After participating in non-majors biology and SI, they expressed positive attitudes about and experiences in science, they performed well in science, and they wanted to participate in more science learning experiences. In some ways, it seemed as though their experiences in non-majors biology and (or) SI facilitated a renewed or re-discovered sense of self as "science person" that was either extinguished or delayed in middle or high school while they pursued other interests and identities. Since it has been reported that the science "talent pool" in general is fully formed by grade 12 and is unlikely to change except for emigration from science (Berryman, 1983), I was interested in what was happening with these women. How did shifts in their science identities (a concept that will be fully developed in Chapter II) influence their transitions to science people? In these limited cases, women have been in my non-majors biology class, utilized the SI program, and have developed an intense interest in biology. The literature is silent on this issue though I theorize that their positive experiences in non-majors biology and SI have stimulated a new sense of self, which includes an increased or renewed affiliation with and interest in science. This apparent shift in identity has caused them to take more science classes voluntarily, leading to a change of major, minor, or education focus to biology. If the non-majors course and SI experience have a role in causing some women to actually immigrate into science, it is reasonable to assume that the SI model is worthy of further investigation and might be generalizable in other contexts to help women enjoy their non-majors classes and develop a true interest in, and appreciation for, science. While the population may be small, there may be potential to draw from a largely untapped resource of women into science although the literature has suggested that this is unlikely to occur. While my pilot study (Warner, 2007) provided a hint that there may have been a science identity shift occurring in these women, I need to know more about if, how, and why this occurred.

Goals of the Study

This research project had two major goals and was designed as a mixed methods study. The first goal of this study was to investigate the meanings of the SI program for successful women who regularly used SI and determining how they perceived the program as being effective for them. While it is clear that SI attendance increases grades, there may be additional benefits that have yet to be determined for this population of women. Hearing directly from the women was the best way to determine the meanings they construct for the benefits SI has afforded them. This goal was achieved by a qualitative analysis of individual interviews with successful women participants who regularly used the SI program throughout their time in non-majors biology. From those interviews, themes were identified and a survey instrument was created. The resulting survey was administered over two semesters to all women who were regular participants in SI. Gathering the perspectives and meanings on SI from a wide variety of women students may be one way to better inform the design and accessibility of SI programs so that a larger audience of students may have the opportunity to benefit from SI.

Previous research would suggest that, perhaps, some women attend SI simply to get better grades, since girls and women are often most concerned about achieving a good student identity rather than a science identity (Aikenhead, 2006; Carlone, 2003, 2004). Yet, based on my preliminary research (Warner, 2007), SI appears to have the potential to transform women's attitudes about, understandings of, and interest in science. This leads me to the second goal of this study which is to investigate the meanings of the SI program as it relates to the transformation of science identity in women. The women interviewed for this portion of the study were regular participants in SI and they decided to change their major or minor to biology or shift their education concentration to science. Investigating the factors, including SI attendance, that influence this transformation in science identity is critical in order to understand how more women can potentially be recruited into the sciences and how more women can have positive experiences in their science educations.

Research Questions

Based on the specific goals of this study, the following research questions were designed:

1. What meaning does SI hold for women who participate regularly in the program?
    a. Why do women attend SI on a regular basis?
    b. How do women describe the *benefits* (affordances) of SI?
    c. How do women describe the *drawbacks* (constraints) of SI?
    d. How do women describe the *learning experiences* in SI?
    e. How do women describe *science* as they experience it in SI?
2. What does SI afford in terms of the science identities of successful women who decided to pursue science further after participating regularly in the SI program?
    a. What are the ways the women connect their experiences in SI with their *interest in science*?
    b. What are the ways women connect their experiences in SI with their *scientific competence*?
    c. What are the ways women connect their experiences in SI with the ways they *define themselves as science learners/doers*?
    d. What are the ways women connect their experiences in SI with the ways they *feel recognized by others as competent science learners/doers*?

The terms and phrases italicized within the sub-questions are ways that I will operationalize the central concepts in my study that are entwined with the meanings of SI for the population of women who participate regularly in the program and for the population of women for which SI may play a role in their long-term interest and participation in science. These issues will be addressed more thoroughly in Chapter III.

Summary of the Chapter

Considering the admitted problems with science education at all levels and the well documented gender bias that is typically associated with the participation of women in science, it is particularly interesting to investigate a program such as SI that has great potential for increasing the satisfaction, academic success, and retention of women in science classes. The extremely skewed gender ratio that has been observed in SI participation at my institution suggests that something about SI provides a unique opportunity for women that may be much bigger than an increase in course grade.

The rationale for this study is that it addresses two major gaps in the current literature. First, SI programs are well established as a means to increase student achievement in the sciences. However, the attractiveness and meanings of the SI program to women has been neglected in the literature. Understanding the meanings of this program to women could be a critical step in learning how to attract and retain more women in the sciences. Secondly, the transition of declared non-science majors to science majors is not addressed by the literature. The literature suggests that these sorts of decisions are established well before college and are not likely to change except for leaving science. This study examined the meanings non-majors biology and SI hold for women who do have a shift in science identities and educational or career goals.

In the next chapter, I will develop a conceptual framework that informs my research questions. The problems with science education and gender inequity will be expounded upon and potential practical solutions from the literature will be analyzed. The history of SI and its many successes will be presented. The concept of science identity will be more fully explained and will be applied to the SI environment and non-majors population.

Operational Definitions

In this chapter and the following chapters, specific terms will be used with a certain assumption about what those terms imply. Those terms are as follows:

Supplemental Instruction (SI)

The term Supplemental Instruction (SI) will be used to describe a specific type of learning experience as described earlier in this chapter. An SI session refers to a small, collaborative group of students who are working together to resolve problems and confusing concepts with facilitation from an SI leader who is a student trained in the SI philosophy and has an excellent understanding of the class content. The program is voluntary in nature and students may attend SI sessions whenever they feel like they need the help. For this study, “regular” attendees of SI participate in sessions about once a week throughout the semester.

Non-Majors Biology

At my institution, non-majors biology refers to a specific course that students take when they are declared as anything other than a science major. While some institutions have mixed majors courses (where majors and non-majors take introductory biology together in the same class), my institution makes a clear distinction between the populations and teaches them using different philosophies, goals, and assessment strategies. At my own institution, the non-majors biology course is always a large class with a typical enrollment of 200 students.

Meanings of SI

One goal of the proposed study is to understand the meanings of SI for regular participants in the program. While certain influences on meanings will emerge based on participant feedback, I am particularly concerned with meaning as it relates to the participants perception of: (a) why women attend SI on a regular basis, (b) the benefits or affordances of regular SI participation, (c) the drawbacks or constraints of regular SI participation, (d) the learning experiences provided by the SI environment, and (e) how science is defined in the context of their SI experience.

Science Identity

The concept of "science identity" will be more fully developed in Chapter II. Identity can be described as "being recognized as a certain 'kind of person' in a given context" (Gee, 2001, p. 99). For the purpose of my study, I am using the concept of science identity as an analytical lens to gain some understanding as to how the non-majors biology and SI environments allow access to science identities for women (e. g. being recognized as a "science person"). Carlone and Johnson (2007) describe a student with a strong science identity by explaining that:

> She is competent; she demonstrates meaningful knowledge and understanding of scientific content and is motivated to understand the world scientifically. She also has the requisite skills to perform for others her competence with scientific practices. Further, she recognizes herself, and gets recognized by others, as a 'science person.' (p. 7)

CHAPTER II

CONCEPTUAL FRAMEWORK

This study presupposes possible explanations for why women have lacked enthusiasm for and persistence in postsecondary science courses. First, the typical structure and design of these courses is not conducive to how students in general (Klionsky, 1998; Lawrenz, Huffman, & Appeldoorn, 2005; Lord, 1997, 2001), and women in particular (Eisenhart & Finkel, 1998; Rosser, 1997; Seymour, 1995b; Seymour & Hewitt, 1997), learn best. As a result of alienating science learning settings, many women do not come to see science as interesting, worthwhile to pursue further, or something that can be relevant for their possible futures. Providing women with appropriate resources to increase their engagement and enthusiasm for science is a potential solution for the attraction of women to college science courses and the retention of women in science. I will develop a line of reasoning that elucidates how Supplemental Instruction (SI) programs align with the needs of women learners and can potentially play a significant role in their success, confidence, and interest in non-majors science classes, and perhaps their long-term interest in science.

This chapter will outline relevant pieces of literature that will help to build my argument that it is critical to: improve non-majors science education for all students, increase the achievement and satisfaction of women in non-majors science courses by offering relevant support programs, and attract the interest of women to the sciences. The organization of this chapter will be structured to provide substantiation from the literature to demonstrate the potential of SI programs in supporting the needs of women learners in non-majors biology classes, perhaps leading towards changes in the ways women come to view and define themselves as science learners.

Outline of the Chapter's Argument

I will begin by using the literature to document the idea that the traditional structure of non-majors science classes is in need of reform and that there is indeed a long history of gender bias in science and science education. The bodies of literature I will draw from include literature documenting the need for science education reform at the postsecondary level, focusing specifically on biology, as well as selected pieces from feminist studies to support the argument that non-majors science classes are not particularly well designed to meet the needs of historically marginalized populations such as women. Next, I will provide a brief history and overview of the success of SI programs to establish evidence that this program could serve as a potential solution to increasing college student success in non-majors science courses, particularly for women.

Using the support of the college science education reform and feminist studies literatures, I will then establish an argument to promote the idea that SI is a critical part of the solution to non-majors students' success, giving specific attention to how this program might impact women. One way to conceptualize the potential impact of SI on women is to examine more closely the effects SI has on their science identities. Thus, I use selected literature to describe the rationale for, and description of, science identity as an analytic lens. In doing so, I build the argument related to SI's potential in transforming the science identities of women who regularly participate in SI.

The Nature of Non-Science Majors Courses

The unique nature of classes designed for non-science majors is a significant consideration when it comes to designing effective learning experiences at the postsecondary level. Knowing that many college students have expressed dissatisfaction with the quality of their undergraduate science courses and instruction (Seymour & Hewitt, 1997), that many non-science majors report that their need for basic understanding of science has not been met in their courses (Advisory Committee to the National Science Foundation Directorate for Education and Human Resources, 1996), and that many entering college students arrive with inadequate knowledge and skills from their previous educational experiences along with lingering misconceptions about scientific concepts (Berkheimer et al., 1990; Roseman & Koppal, 2006) is a certain sign that the typical approach to undergraduate science education needs to be reconsidered. The following quote from Tobias (1992a) provides a succinct summation of the many identified targets for science education reform at the postsecondary level:

> What hinders students are the pace, the conflicting purposes of the courses; attitudes of their professors and fellow students; unexplained assumptions and conventions; exam design and grading practices; class size; the exclusive presentation of new material by means of lecture; and the absence of community. (p. 18)

The American Association for the Advancement of Science's (AAAS) Project 2061 has long been concerned with science education reform. While many of their recommendations are applied to K-12 science education, there is much that can be applied to undergraduate education. In AAAS's *Science for All Americans* (1990) "science literacy" was promoted as a top priority for high school graduates. According to the *National Science Education Standards* (National Research Council, 1996), science literacy is characterized by specific content standards and dispositions with the stated purpose of science literacy being to provide an individual with the tools necessary to make personal decisions, to participate in cultural and civic affairs, to engage in intelligent discourse and debate concerning scientific issues, and for economic productivity.

Postsecondary institutions were charged to develop a curriculum that surpasses that of science literacy goals of high school graduates. However, many freshman and sophomores at the college level have not yet met the goals of science literacy for high school graduates (Roseman & Koppal, 2006) making introductory, and particularly non-majors science classes, a logical place for curriculum reform to support the continued development of science literacy. As an instructor of non-majors biology, and given that my class is likely to be the last science class my students will ever take, my primary goal is to increase the science literacy for all students in the class so that they will come to have an appreciation for the sorts of benefits scientific understanding and reasoning can afford them. As adapted from the *National Science Education Standards* (National Research Council, 1996), my interpretation is that students with a well developed science literacy have an understanding of the nature of science, are comfortable in applying their science knowledge to unfamiliar situations, can engage in meaningful scientific discourse, and can use science to help them make personal decisions. Given a typical fifteen week semester, this becomes an arduous goal to achieve in such a brief period of time.

While I believe non-majors biology courses should be designed to increase all students' science literacy, I have also observed an interesting trend related to the science pipeline occurring each semester I teach the class. Nearly every semester, I have a small group of students whose interest and success in non-majors biology and SI sparks a new or renewed desire to pursue science further. These students, nearly all of whom are women, decide to either: switch their major to biology, switch their minor to biology or decide to pursue a career as a science teacher. Thus, in these cases, participation in non-majors biology and SI became an impetus for some women's continued pursuit of science. In a few of these cases, women who were not planning to do so end up entering the science pipeline. Thus, interestingly enough, non-majors biology and SI become gateways for some students to enter the science pipeline. I suspect many higher education faculty would be surprised about these "non-majors" science education experiences serving such a role for students as this is not a trend addressed by the literature. I would argue, however, that we need to closely examine what about these science education experiences seems to be working because, as I describe below, the typical non-majors biology course (not supported with SI) is not often set up to reflect what the science education literature touts as best practice.

Critiques from the Science Education Reform Literature

At the postsecondary level, a tremendous amount of power is in the hands of the individual instructor as choices they make concerning approach, level, and pedagogy used have a tremendous impact on the effectiveness of a course (Moore, Jensen, & Hatch, 2001). In terms of making these choices, the depth versus breadth issue makes for a spirited debate. Traditionally, non-science majors have been taught a diluted version of a science major course created by modifying the curriculum for a major course by removing certain details to create the non-majors version. This is reflected not only in the teaching styles selected by instructors but also by many textbooks marketed for non-science majors. Some of the most popular non-majors biology textbooks (Campbell, Reese, & Simon, 2007; Mader, 2007; Starr & Taggart, 2006) were adapted from lengthy traditional biology majors texts (Campbell & Reese, 2008; Mader, 2007; Starr, 2007) by, in my opinion, simply removing some of the details. However, the instructors' and textbooks' general structure and approach remain remarkably similar to the majors' courses, with an overwhelming emphasis on de-contextualized content knowledge. The question is, do non-majors students really need this level of detail without context in their course? While there are varied opinions in the literature, it has been argued that a heavy content knowledge approach is not necessary for the non-majors student (Sundberg, Dini, & Li, 1994; Yager & Lutz, 1994) and that reducing the collection of facts for students to learn in these classes generally increases student understanding (Lujan & DiCarlo, 2006). I believe Klionsky (2004) best encapsulated the issue when he stated he is "not convinced that it is important to cover 'everything' if the students are not learning anything" (p. 209).

Another criticism of college science instructors is that they have traditionally relied on pure lecture and involved little to no interactivity or innovative teaching techniques. In fact, Klionsky (2004) asserts that teaching styles have changed very little since before the invention of the printing press. The level of student satisfaction and attitudes towards science taught by traditional lecture is generally low (French & Russell, 2006). This begs the question of why we continue to instruct using this method. In an online survey of 230 full-time college math and science professors at four year colleges in Louisiana, Walczyk and Ramsey (2003) found that the use of learner-centered teaching techniques was very low. In a later study Walczyk et al. (2007) investigated the reasons for such limited use of learner-centered strategies by surveying 235 math and science professors at four year colleges in Louisiana. In this 2006 study, some of the sample population was the same as the 2003 study and some respondents were new faculty. Two of the common rationales cited for resisting new teaching methods included a perceived lack of importance to teaching as it relates to promotion and tenure issues and a lack of training in good pedagogy.

Another reason commonly cited by instructors using a traditional lecture format is the limitations of class size (Klionsky, 2004). Non-science major courses are typically part of a general education core, and many colleges and universities offer these courses in sizes from 100 to more than 500 students per section (online registrar's data for Fall 2007 enrollments at University of Southern California, University of North Carolina, University of Missouri, University of California-Los Angeles, and Michigan State University). As evidenced by the large number of students enrolled per section, many colleges and universities are being forced to offer high demand or required classes by teaching them in large sections. In a class section of this size it is undeniable that there are many challenges that arise for both the students and the instructors. Unfortunately, there is no easy solution for how to reduce class size given increasing enrollment and a limited number of faculty members at most institutions.

When discussing non-science majors course design, we must keep in mind its population. Many non-majors students report negative experiences in earlier science courses (Congos et al., 1997) which may be one potential explanation for their decision not to major in science. Understanding that many students who chose not to major in science have had less than positive experiences with science in the past, which may have biased them before they even walk into a science class on the first day of the semester, is important when designing the course. Couple this bias with the trend towards increasingly large class sections, and a very impersonal and irrelevant experience can be what students expect. This sort of experience can lead to a certain amount of anxiety for the student that often leads to poor performance in the course (Mallow, 2006). The major contributing factors to the anxiety expressed by many non-majors are: negative messages about science that they have received throughout their academic experiences, the promotion of the idea that science is for an elite few, the lack of significant training in analytical thinking, and the direct steering away from "difficult" science courses (particularly for women students) by high school counselors (Mallow, 2006).

In 1989 the Standards in Teaching Biology Committee was established. The committee consisted of six members of the National Association of Biology Teachers (NABT) as appointed by the president of NABT. The charge of this committee was to develop national recommendations concerning college level biology teaching as supported by research evidence. The recommendations of the committee were as follows:

> Introductory biology classes should be examined and redesigned; the classroom environment should encourage students to achieve; classes, particularly at the introductory level, should be small; faculty should be rewarded for high quality teaching; and an examination of the total undergraduate curriculum should be conducted. (Gottfried et al., 1993)

These recommendations make it clear that there is a problem with the typical design of these courses and that there are potential solutions. However, some of the trends in science education are in direct contrast to the recommendations. In particular, the class size issue is moving in the direction of larger instead of the smaller size suggested by science education reform literature and there is still the tradition of clinging to instructor-centered pedagogy.

Summary

Realizing that the needs of non-majors students are different from those of science majors is an important first step in making positive changes towards increasing student satisfaction and achievement. Given the large audience of non-majors students and the call for science literacy, it seems completely appropriate to express some concern over how these courses are designed and delivered and to find better ways to deal with the problems typically associated with high enrollment classes, while also recognizing the limitations associated with a lack of sufficient faculty and resources. Given that one common complicating factor for many institutions is large class size, it is prudent to investigate opportunities such as SI that find ways to get students in small groups, even within the large class confines, to enhance their learning.

In the next section, the history of gender bias in science education will be examined in an attempt to explain how women may have been failed by their science educations. We know that postsecondary science education has been criticized for its traditional approach to teaching science which has less than optimal consequences for many populations of students. However, it is important to examine what feminist scholars say on this issue as the traditional approach to teaching science seems to have a greater impact on women, ultimately turning more women away from science than men (Seymour & Hewitt, 1997).

History of Gender Bias in Science Education

Science has traditionally been considered a male-dominated field. Several studies have shown this gender bias to establish itself in elementary science courses as a result of a variety of sociocultural variables. Andre et al. (1999) developed and administered a comprehensive survey on beliefs concerning science as well as a competency measure in science to three groups of students and parents: kindergarten through third grade, and grades four through six. In total, 238 male students, 199 female students, 271 mothers, and 76 fathers were included in this study. The results suggested that parents strongly believed that science was more important for boys, and they expected higher performance of boys in science as compared to girls. While boys tended to be more competent in the sciences, this study found that girls and boys both liked science equally. Knowing that girls are as interested in science as boys, but that girls have a more negative attitude about science, speaks volumes concerning the ineffectiveness of the traditional structure of science education for typically marginalized groups such as girls.

Another study involving 437 sixth graders (Jones et al., 2000) examined the attitudes of students concerning science education and science careers. Boys in this study reported that science was more suitable for boys than girls and that they were concerned about control and earning money when making a career choice. Girls reported that science was difficult to understand and only expressed an interest in scientific careers for the sole purpose of helping other people. Differences were also noted in the types of scientific activities boys and girls engaged in on a voluntary basis.

As a consequence of early educational experiences, women report low perceived ability in science (Brickhouse, Lowery, & Schultz, 2000; Oakes, 1990; Seymour & Hewitt, 1997), negative attitudes toward science classes (Alexakos & Antoine, 2003; Hanson, 1996; Oakes, 1990), and a lack of motivation to pursue advanced studies in science (DeBacker & Nelson, 2000). Research shows that girls do not receive the same quantity or quality of science education as compared to male students and that girls are discouraged from participating in science (Oakes, 1990; Tindall & Hamil, 2004). This bias has been observed at every level of education from preschool to postsecondary. Teachers interact more with males, encourage males to participate more, give more feedback to males, and encourage more critical thinking in males (Guzzetti & Williams, 1996) so that it is no surprise that boys have a more positive attitude towards science than girls (Weinburgh, 1995). According to Woolfolk (2001), men are two times more likely than women to initiate comments in science classes at the college level and women have received 1800 hours less of instruction and attention than males at the end of high school. Over time, women's participation in science diminishes at a steady rate particularly through high school and continuing in college (Hanson, 1996; Oakes, 1990). Young men are three times more likely than young women to aspire to major in science by the time they are high school seniors (Xie & Shauman, 2003). It is no wonder that women enrolled in science classes for non-science majors experience anxiety about their ability to succeed in the course based on their previous school-based science experiences.

Theories to Explain Gender Bias in Science Education

There are many theories to explain the lack of women pursuing science majors and careers. Most of these theories take into account a variety of social, cultural, and affective domain influences. Essentially, these theories explain the lack of women in science by suggesting either that: (a) there is some sort of deficit with the women, (b) there is a problem with science, or (c) there is a problem with classroom climate and pedagogy. I will explain each of these theories followed by an explanation as to why this study focuses specifically on classroom climate and pedagogy as a promising solution for the gender problem in higher education science courses.

One school of thought on why women are underrepresented in science relates to there being a "problem" with the women. While this is not a position I plan to align with, it does offer one potential explanation. Essentialist feminist theory focuses on biological differences between males and females including differences of secondary sex characteristics and reproductive systems (Rosser, 1997). This perspective supposes that biology provides a reason that women are able to learn certain types of content better than men, and vice versa, and focuses on the problem being a result of content constraints as opposed to the learning environment (Rosser, 1997). However, the trend with many feminist scholars is to eschew the pure essentialist perspective in favor or a more moderate perspective on gender issues (England, 1999).

A second explanation for the lack of women in science relates to a problem with science and the mismatch that occurs with women's gender roles contrasting with the masculine gender roles expected in science. The nature of science itself has been described as being masculine (David, 2005; Namenwirth, 1991), competitive (Seymour & Hewitt, 1997), and impersonal (Brickhouse et al., 2000). Existentialist feminist theory would suggest that women are disadvantaged in science not due to biological differences, but instead by the social construction of gender roles based on society's interpretation of biological differences (Rosser, 1997). These imposed gender roles ultimately have an influence on learning styles and preferences for women (Eisenhart & Finkel, 1998; Rosser, 1997). Boys and girls are treated differently from birth (Sadker & Sadker, 1994) and this continues throughout life. Society's imposed gender roles and feminine expectations of women can be in conflict with the masculine nature of science (Brickhouse et al., 2000). Women are not expected to be assertive, aggressive, and competitive in society as this does not align with our ideas of what feminine is supposed to be, however, they are expected to be these things in science. This generates a major conflict between the expectations of society and the expectations of science.

A third explanation for the lack of women in science relates to classroom pedagogy that enforces the perception that science is difficult, competitive, and not relevant, which leads to a perceived negative classroom climate for women. The profile of typical students interested in the sciences tends to involve high Scholastic Aptitude Test (SAT) math scores, a high grade point average (GPA) in high school, and previous enrollments in science courses (Seymour, 1992a). When males and females are matched for equal academic qualifications there is a lower interest of highly qualified women in science than men (National Science Board, 2004). Seymour (1992a) provides several rationales for why highly qualified women abandon science. Those reasons are: that other disciplines are of greater interest, a general lack of interest in science, and a rejection of the perceived lifestyle associated with scientific careers (Seymour, 1992a). Further, in a comprehensive study interviewing more than 400 science majors (over three years on seven campuses) who either retained a science major or were “switchers” to a non-science major, it was found that in both the switcher and non-switcher groups that everyone was academically highly qualified and that nearly everyone was frustrated by the competitive nature of science classes and the non-supportive culture (Seymour & Hewitt, 1997). While some students persisted in their science major despite their frustrations, a disproportionate number of highly qualified women (50% in the biological sciences) switched their majors out of science citing a perceived difficulty level in science, a low self-rating of analytical ability, and a low tolerance for receiving poor grades (as is typical in most introductory science courses). With such a high number of women leaving science majors, it emerged that there was a misfit between socially constructed expectations of women versus the expectations of their faculty and male peers as well as versus that of the purpose and nature of the undergraduate experience in science majors (Seymour, 1995a). Seymour and Hewitt (1997) also contend that there is no deficit in the women and it is not the difficulty of science courses that are a problem even if the women perceive a high level of difficulty. Instead, it is the pedagogy that turns the women away. The perceived hurdles in the class coupled with a lack of relevance to students make retention a problem. Seymour and Hewitt (1997) concluded that the two factors that will keep women engaged in science are the pedagogy used by the instructors as well as a positive perceived classroom climate.

Unfortunately, many college classrooms have a perceived “chilly climate” for women. The chilly climate has been described as a classroom where women feel less welcome than men which causes women’s participation in activities and discussions to be suppressed (Hall, 1982). The underlying cause of the chilly climate is rooted in social practices that lead to differential expectations of male and female behaviors and these social practices are often reinforced by college instructors (Hall, 1982). Constantinople, Cornelius, and Gray (1998) assert that this chilly climate is not as drastic as some would claim. They explain that the degree of the chilly climate is dependent primarily on the class size, with larger classes leading to a more chilly climate, and the gender of the instructor, with women participating more in large classes with women instructors. When class size was small, the gender of the instructor had little impact on the climate for women in the class.

The lack of women in science is certainly attributable to a variety of factors. I reject the idea that the women have some sort of innate deficit. While I believe that the nature and culture of science may not be well aligned with the societal gender roles and expectations placed on women, I also recognize that this is a much larger influence than can be explained by this study. Viewing classroom climate and pedagogy as a major influence on women's lack of interest in science is the most appropriate lens to inform my study. I favor this way of understanding the gender bias in science, primarily because it affords educators the ability to make changes that can make real differences for women. The sorts of changes suggested by the science education reform literature have the potential to increase the retention of all students in science with the additional benefit of being particularly attractive to women.

Ties to My Study

At this point, I have established that there are problems with the traditional approach to non-majors biology by drawing on the science education reform literature. I also reviewed the gender bias in science and science education. For me, the key issue at this point is that more than half of all highly qualified women are leaving science, citing bad teaching and a chilly classroom climate as their reasons (Seymour & Hewitt, 1997). Knowing that the trend is for women to emigrate out of science majors, I am particularly intrigued by the women who resist the trend and immigrate into science even after declaring themselves non-science majors. With the allegation that the science "talent pool" in general is fully formed by grade twelve and is unlikely to change except for emigration from science (Berryman, 1983), it was intriguing to examine more closely the women who defy expectations by entering the science pipeline at this late stage.

In the next section, I will discuss the SI model and present selections from the literature supporting its effectiveness as a tool for increasing success and satisfaction in high risk courses such as non-majors science. Of particular interest will be ways that this program may meet the needs of women learners and perhaps, in some way, contribute to the immigration of some women into science instead of away from science.

Existing Literature on the Effectiveness of Supplemental Instruction

Supplemental Instruction (SI) programs are small, peer-based learning environments targeted towards classes that have a history of high enrollment, high withdrawal rates, and high failure rates. The SI programs are typically run through campus Learning Centers where SI leaders are identified and trained. Students who become SI leaders have taken the class for which they want to be a leader, done very well in the class, and generally are considered model students. The leader is trained and then leads multiple SI sessions each week for the students enrolled in the class. The leader's role in the sessions is to facilitate problem solving by helping the participants help each other. The program is voluntary in nature and any student can use SI for help at any time during the term.

SI has a long history of being effective at improving motivation, student grades, and satisfaction in high risk courses (Blanc et al., 1983; Congos, 2003; Hensen & Shelley, 2003; Van Lanen & Lockie, 1997). Some hypotheses as to why this program improves student performance are that the learning environment is peer-based and non-threatening, that the SI sessions are small groups and allow for more personal attention, that SI encourages further small group study outside of class, and that SI had no "remedial" stigma attached to it so students feel comfortable using the program. SI has the additional benefit of teaching skills that are transferable to other courses that the student might take (Ogden et al., 2003; Price & Rust, 1995; Ramirez, 1997).

While survey data has been collected in order to determine levels of student motivation, student satisfaction, and benefits in later courses from SI participants, there has been little in terms of qualitative investigation into the meanings of SI programs for the participants. Most of the research on SI has been purely based on comparisons of course grades between students who attended SI and those that did not. This research indicates that those that attend SI typically make at least one half to one letter grade higher in the course as compared to students who do not use SI (Blanc et al., 1983; Collins, 1982; Congos et al., 1997; Congos & Schoeps, 1993; Hodges & White, 2001; Ogden et al., 2003; Shaya et al., 1993; Zaritsky & Toce, 2006). It had been previously suggested that the SI program produces increased course grades for attendees because the program self-selects for "better" students to attend and that these students would have done well in the course even without SI support. The current research suggests that SI does not self-select for better students and that all students can improve their course performance by using SI (Congos & Schoeps, 1993; Congos et al., 1997; Gaddis, 2002; Shaya et al., 1993). There have been limited studies on specific populations of students and their participation in SI programs. High risk and minority students have been examined as sub-populations of SI attendees but the primary factor studied was again course grade at the end of the semester (Shaya et al., 1993; Hodges & White, 2001; Rath, Peterfreund, Xenos, Bayliss, & Carnal, 2007). Further, some of these studies made SI a mandatory part of the course which is in conflict of the SI model which promotes voluntary attendance (Ramirez, 1997; Schaefer & Hopper, 1991). While these studies showed a greater impact for course grade increases for marginalized populations who use SI, there has been no discussion of the meanings of the program for these attendees or possible benefits other than an increase in final course grade or augmented study skills.

Only one study to date has addressed the specific issue of women's participation in SI programs. Lundeberg and Moch (1995) reported that SI provides a sense of community and connectedness which motivates students to participate in the program. The primary limitations of this study were that it was done in a nursing program where students seem to have different levels of motivation to begin with, and that the study was conducted at a private, women's institution. While interesting female perspectives were unveiled in this study, they may not be broadly applied to all women. Understanding how SI programs are perceived by women who are not enrolled in professional programs (such as nursing), who have differing levels of motivation, is an important task.

Ties to My Study

During my career as a non-majors biology instructor, I have taught more than 40 large sections of non-majors biology (with a typical enrollment of 200 students per section) and nearly all of them have been supported by SI. I have worked closely with this program for nine years and have modified the SI model for my population of students. I meet and train my SI leaders every week, have attended meetings of all campus SI leaders to gain insights into how the model is (or is not) working well in other settings, regularly observe SI sessions, and have had many conversations with the director of the SI program to discuss trends and issues that have been raised by SI leaders and participants.

My Adjustments to the SI Model

With non-majors science courses in particular, it is not unusual for many students to struggle with the material. In my past experience, many students would come to SI sessions so confused that they could not even articulate a question for the group, making them even more frustrated with the material and themselves. The traditional model of SI is designed exclusively as a peer-based model where the SI leader does not interfere or lead discussions. As a result of how my students participated (or did not participate) in SI using the traditional model, I have made a few modifications to the model which seem to be of benefit to the students that attend. These enhancements are used for all SI sessions for all non-majors biology students at my institution. A summary of these enhancements can be seen in Table 1.

Because my SI participants are varied in so many ways including their levels of understanding, I find it beneficial to provide a practice "quiz" at the beginning of each SI session. The questions are exam-type questions and the students get a few minutes to come up with answers individually. This gets them thinking about the material and generating questions about the material. These "quizzes" are not collected or graded so they are low stakes and low pressure. Next, the students get into small groups and discuss the questions, trying to negotiate any differences in answers and helping each other.

Table 1

SI Modifications

	Traditional SI Model	**Modified Version of SI**
Identification of SI leaders	Student self identifies to learning center or is recruited by learning center – instructor may not be involved in the process	Intensive screening and invitation by instructor who then makes referral to the learning center
Interaction of SI leaders and instructor	Highly dependent on the instructor, but often there is not much communication	Weekly meetings between SI leaders and instructors as well as extensive email communication
Number of SI leaders	Most courses have a single SI leader	My course has two SI leaders per semester which allows students to attend the sessions with the leader they feel most comfortable
Availability of SI sessions for students	A typical course would offer four SI sessions per week	Because I combine my sessions with a colleague, we are able to offer eight SI sessions per week
Promotion of the SI program	Typically mentioned to students by instructor and schedules are posted	High level of promotion by instructor in class, via website, and via reminder emails
Role of the SI leader during sessions	Facilitator only	Facilitator, but will step in to clarify if no other students in the group seem able to help
Structure of SI sessions	Student-driven where the session is dedicated to students helping each other answer questions	First few minutes are spent on complex problems. This allows a focus on topics that are not well understood and provides a launch for student questions.
Attendance	Completely voluntary	Voluntary, but with incentive of 1% extra credit added for those who attend regularly over the course of the semester

While some questions may be clarified, new questions may develop at this point. Finally, the SI leader gets involved and helps the group resolve their questions. I have found that this type of structure provides a non-threatening, collaborative environment that most students seem to enjoy. It also encourages their participation in the session and with each other. The students also appreciate getting the extra practice materials which helps them learn test-taking strategy and boosts their confidence, especially for students with testing anxiety. Further, during tense times such as exam weeks or when a particularly difficult concept is being presented in class, I develop games and activities for the SI session in an attempt to facilitate group learning while making the environment fun and enjoyable.

There is one additional modification I have made to the SI model. I have found that some of the students who need the support of SI the most may not be motivated to attend because they do not yet see perceived value to spending their time attending an optional program. I wanted to find a way to get these students to show up just once to an SI session. I felt confident enough that if I could get them to attend once, they would see the value of the program and continue attending. So on the first day of class when I tell the students about SI, I offer them a small incentive to show up to a session at the beginning of the semester. If they attend SI once a week for ten of the fifteen weeks in the semester, I offer them an extra credit boost equivalent to one percent of their course grade. This extra credit is almost negligible in terms of impact, but it gets them in the door at SI and coming back for more. Of course the continued attendance at SI increases their course grade all semester which is the intended outcome. With my heavy promotion of the program as well as my willingness to give a small reward for attendance, many students at least try the program. This incentive certainly won't convince all students to try SI, but I have found offering a small incentive does reach some students who truly need the help that SI can offer.

Summary

My personal observations with SI have revealed that participation in SI for my non-majors biology classes by female students far exceeds participation by male students to the degree of many SI sessions are attended only by women. In most semesters, at least half of my students get help in SI at least once and at least 25% of them become regulars, attending SI about once a week during the semester. Stephens (1995) suggested that women who actively participate in SI associated with math courses tend to benefit in terms of grade improvement more so than males. Perhaps the same advantage holds true for women who use SI for biology courses. Attendance at SI seems to be an important factor in achievement and satisfaction with my own courses, particularly with women students (Warner, 2005).

While it is important to show that SI programs do support achievement in a course, I also feel that it is important to understand a largely ignored area within the SI literature - the meanings SI holds for its regularly attending participants. In other words, while much of the literature cites the effectiveness of SI on student achievement, there is no literature that attempts to understand why or how SI affects student achievement and interest in science. SI is often treated as a black box, mysteriously producing desired outcomes of student achievement. As I describe later, my study, by examining the meanings SI holds for its participants, will begin to look inside the black box.

In the next sections, I will discuss suggestions from the reform-based science education literature on best practices for supporting the achievement and success of students in the college classroom. This information will be used to scaffold an argument that the structure of SI programs is well aligned with best practices to support the educational needs of college students. My primary focus will be on the unique aspects of SI programs that are particularly well aligned with women's learning preferences.

Alignments of SI with Reform-based Science and Learning Theories

There are a variety of suggestions in the science education reform literature concerning how to improve science classes at the postsecondary level. Some of those suggestions include promoting critical thinking skills and utilizing active methods of learning by using cooperative and constructivist learning strategies. A limited overview of these learning strategies will be offered in this section. Later, the relationship of these learning strategies will be discussed as they relate to the SI philosophy and learning environment.

Promotion of Critical Thinking as a Means of Increasing Science Literacy

Increasing critical thinking skills in students is often cited as one way to increase science literacy. In considering the role of critical thinking in any setting it is first necessary to define exactly what the term "critical thinking" implies. This is a difficult task as there is no set definition for what constitutes thinking critically. In my own experience, I have found that no two people define critical thinking in the same way and that most educators create their own definition and design their courses and pedagogy based on their own interpretation of the term. To further complicate the issue, different disciplines may have different ways of approaching critical thinking. The following is a definition of critical thinking provided by the American Philosophical Association (1990):

> the process of purposeful, self-regulatory judgment, which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based.

I favor the more streamlined definition provided by Baxter Magolda (2003) that describes critical thinking as something that "requires the ability to define one's own beliefs in the context of existing knowledge" (p. 233). While this definition is open to interpretation, I think it clearly reflects my own opinion that thinking critically requires one to take their existing and familiar knowledge and use that knowledge to define their own beliefs in an unfamiliar setting.

In terms of science education, critical thinking is a requisite component of science literacy. Baxter Magolda (2003) has claimed that critical thinking is "the most agreed upon goal of higher education" (p. 232). This type of learning leads to students who are more prepared to face unique problems than those students whose knowledge is based solely on the memorization of a collection of facts. However, there are some reported difficulties with promoting critical thinking.

One problem is that many students have been disadvantaged by their previous educational experiences leading them to being less than prepared for thinking critically (Berkheimer et al., 1990; Cheung, Rudowicz, Kwan, & Yue, 2002; Moffat, 1994; Roseman & Koppal, 2006). When students have not been adequately prepared for this type of thinking, I suspect it may become difficult for them to adjust to that expectation in college. Further, in a large class setting, the instructor has less time to devote to individual students to help promote their critical thinking skills. While promoting critical thinking skills is a laudable goal in high enrollment classes, it is not always used as instructors frequently cite a lack of time as to why they do not implement more critical thinking activities into their large classes (Shell, 2001). Because well designed critical thinking activities require individualized and frequent feedback, smaller settings such as SI make critical thinking activities somewhat easier to implement. The SI setting allows for regular and immediate feedback as students try to solve vexing problems.

Integration of Cooperative Methods of Learning

The literature uses many terms interchangeably to imply cooperative, collaborative, constructivist or active learning. In its most simplistic terms, cooperative learning implies an active process involving collaborative work within a group for a common goal. I borrow the definition of cooperative learning from Johnson, Johnson, and Holubec (1994) which describes cooperative learning as the use of small groups that allows students to work actively and collaboratively to maximize their learning as well as the learning of others in the group. This definition allows for flexibility in what constitutes cooperative learning and emphasizes that the goal is to maximize learning for all members of the group which differentiates the cooperative learning experience from simple group work. I will present selections from the literature to promote the usefulness of cooperative learning techniques followed by an explanation of how the SI environment aligns with these learning techniques.

Klionsky (1998, 2002, 2004) has offered specific suggestions for improving biology teaching by the use of cooperative learning methods in the classroom. His study (1988) involved a class of 300 students who were taught by lecture and then later broken into collaborative groups of 35 students with each group being led by a teaching assistant. There was a reported 86% rate of student satisfaction with the collaborative format although student frustrations were also expressed relating to lack of time, a group size that was too large, other students in the group not being on task, and lack of preparation. Others (Caccavo, 2001; Ebert-May, Brewer, & Allred, 1997; Udovic, Morris, Dickman, Postlethwait, & Wetherwax, 2002) have come to similar conclusions concerning the effectiveness of cooperative learning in introductory science courses.

Tessier (2007) allowed a large class of non-majors biology students to alternate between class periods of traditional lecture instruction from the professor and class periods of small-group peer teaching (SGPT). On the SGPT days, students broke into small groups and were given questions to answer. They were expected to work together and use their resources to come up with answers. Then, they were to teach the topic to the other members of the group. When exams were constructed, Tessier created questions that related to his lectures and questions related directly to the SGPT topics. He found that students performed better on the questions that related to the topics they taught themselves via SGPT. It was also revealed that students with the lowest grades in the course, presumably at highest risk for failing, had the greatest increases in their scores based on the SGPT model.

Lord (2001) has performed a review of the literature concerning cooperative learning and other alternative teaching methods and has concluded that they are generally more effective than a traditional lecture-based course. His review was comprehensive and considered the literature in support of cooperative learning as well as the literature repudiating the use of cooperative learning. He identified eleven major categories of outcomes supported by cooperative education. After elaborating on these eleven major themes, a total of 101 benefits of using cooperative learning were presented.

Clearly there is support from the literature to suggest that students are more satisfied with, and achieve more, as the result of cooperative learning experiences. In the specific examples from the postsecondary science education reform literature provided in this section, the structure of the cooperative learning approach was different in each case, yet the positive outcomes for students were the same. This suggests an important parallel with SI programs which are designed specifically to support cooperative learning techniques. SI sessions are purposefully designed to promote cooperative group learning as each session requires students to work within small groups. Even for students who are taught by traditional instruction in large lecture classes, SI provides an opportunity for students to experience cooperative learning and perhaps to benefit from this experience in their large classes.

Constructivism

The term constructivism can have many meanings, some of which are very narrow and specific to how people learn, and others which are very broad in scope and are applied to the nature and perception of reality. While some constructivists consider this theory of learning to extend to the construction of reality in all aspects of life, my focus is limited to how the basic principles of social constructivist theory can be applied to the science classroom to help students develop problem solving skills and increase their personal knowledge and appreciation for the discipline, in turn increasing their science literacy.

The classroom constructivist approach is almost always student-centered, inquiry based, active and collaborative in nature. The assumption is that a group of unique individuals with different experiences will complement each other and help to construct a higher level of knowledge than could be achieved on their own. Students are allowed to challenge current thinking and to form their own unique solutions to problems. Overall, constructivism refers to a way of learning by using the unique experiences of individual students to help them "construct" knowledge as opposed to having it "told" to them by an instructor.

Social constructivism in theory. The foundations of social constructivist theory were developed by Vygotsky and his research on development in children, however, the principles of his theory could easily be extended to postsecondary learning. There are three principles to the theory of social constructivism (Vygotsky, 1978). The first principle deals with using the culture of the community around the student as a way for the student to make meaning of knowledge. The second principle deals with tools that surround a student. These tools vary from the quality of instructors and more advanced students, to the language and culture of the group, each of which determines the rate of development of the student. The last principle is referred to as the zone of proximal development described as the "distance between actual developmental level as determined by independent problem solving and the potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 96). This essentially means that when a weaker student receives help from a teacher or more advanced student they can master concepts they would not be able to grasp on their own. By using the tools and culture of the group, an individual is able to incorporate those tools as their own and advance to a higher level of understanding. Instructors and more advanced students are creating what Vygotsky referred to as scaffolding to help students move through their zone of proximal development.

Social constructivism in practice. Lord (1997) has compared the differences between class environments of traditional and constructivist formats and found that students taught by constructivist methods performed better on assessments, had more positive attitudes towards science, and reported a higher level of satisfaction with the course. These conclusions were validated by Klionsky (1998) who also found that students taught in a constructivist manner reported a more positive experience in introductory biology courses than those taught by traditional methods. The students also reported a higher interest in continuing with biology at the end of the semester. A similar study performed at the high school level (Lloyd, 1996) showed that student satisfaction and achievement of science literacy was better fostered by a constructivist environment as compared to a traditional format.

Colburn (2000) points out some unique advantages that constructivist teaching strategies can produce in the science classroom. Allowing students to work and inquire as a group allows them to build on their preconceived ideas as well as to have flaws in their logic discovered and corrected by other students in the group which is less threatening than being individually challenged by an instructor. This format allows students to develop a deep understanding of scientific content while making them feel that their contribution to the group was important (even if it was not completely correct) to the overall learning experience. This approach promotes a positive attitude towards learning science and helps demonstrate the relevance of science to real world experiences. Scheurman (1998) and Skrtic, Sailor, and Gee (1996) all point to the additional benefits of a constructivist learning environment for students who come to the class with weaker skills. The constructivist atmosphere allows them to contribute in their stronger areas and to be supported by members of their group in weaker areas. In large classes in particular, it is very likely that the diversity in learning abilities will be quite pronounced amongst the group. The constructivist approach allows weaker students to increase their confidence and have a better chance at success in the course while affording stronger students the ability to increase their skills by assisting the weaker students. In this environment, Scheurman (1998) and Skrtic et al. (1996) argue, students of all levels can benefit.

While teaching techniques that support constructivist learning have plenty of support in the literature, there are some potential limitations. In Bianchini's (1997) study of constructivist group work in sixth graders, it was found that students with high perceived levels of popularity and ability were more active participants in constructivist groups and had higher levels of achievement. Students in the constructivist groups also were found to have difficulties making connections between science and the real world. Bianchini suggested that students need more guidance when using constructivist groups that assists them in learning to talk about science and understand how science is done. While this study focused on middle school students, I feel that it is still relevant for introductory college science students who may have had little exposure to talking and thinking scientifically in their previous educational experiences.

Having discussed some of the academic benefits of using constructivism in the science classroom, it is appropriate to consider some of the social benefits that come from this method. Allowing students to work together in groups promotes social skills as well as a sense of loyalty to the group and a sense of ownership to the knowledge scaffolded and constructed by the group. When the combination of group members is diverse in nature, such as with differing levels of cognitive development and scientific knowledge, everyone involved can benefit. Marlowe and Page (1999) describe the advantage of diversity in the group by stating "the value of constructivism is that it respects and allows each student to use his or her unique knowledge and experience in the learning process" (p. 20).

Ties to My Study

I have already established that the SI model is in alignment with cooperative learning principles that afford students benefits in terms of satisfaction and achievement with science. Additionally, I argue, a well structured SI environment provides the setting conducive for constructivist learning to occur. As part of my own modifications to the SI model discussed in a previous section, I provide students with challenging problems at the beginning of each SI session. These problems are meant to help students identify areas that are troubling to them. Following the brief individual effort on the problems, students work in collaborative groups to attempt to resolve their areas of confusion. Members of the group and the SI leader can provide scaffolding for others who are less confident in their knowledge which assists students in working through their zones of proximal development. By working together, the members of the group are assisting each other in constructing and elaborating on their own knowledge.

The diversity within most college classrooms provides an excellent opportunity to apply Vygotskian principles allowing those with different backgrounds and perspectives to come together as a group in order to advance the knowledge of individuals within the group. Social constructivism can be a powerful tool in affording the students a more positive learning experience as well as a deeper understanding of scientific concepts that cannot typically be gained through traditional teaching formats. The social environment emphasizes the unique contributions that each member of the group can make towards overall learning and promotes inclusion of all members of the group. The more social format allows marginalized groups such as women to feel more comfortable with contributing and provides an environment that is more equitable than a traditional classroom.

Teaching strategies that facilitate constructivist learning can be particularly attractive to female students. Barton and Osborne (1999) suggest that using constructivist approaches can drastically facilitate the inclusion of women and improve their performance in science classes. The use of constructivism in science classes may be one small step towards decreasing the gender bias that is prevalent through all levels of science education. The SI environment is a perfect example of a setting where constructivist methods can be applied. Clark (1998) reports that students tend to spontaneously develop inclusion within constructivist groups. They are bonded by their common situation of facing an unfamiliar experience of what to expect in the course. Clark (1998) states that "people flourish in an atmosphere characterized by safety, trust and care, mutual respect, and a balance between familiarity and novelty, reassurance and challenge" (p. 94). Unlike traditional formats that reinforce submissiveness and dependence on instructors, constructivist groups allow students who might never feel comfortable participating in a traditional class format to feel comfortable contributing to a small group (Marlowe & Page, 1999).

The social organization of SI makes it a likely candidate for increasing students' knowledge and understanding in science based on current learning theories. In addition, however, SI's structure also aligns nicely with what we know about the learning environments where women learn best. I will discuss these alignments in the next section.

Potential of SI in Light of Women's Ways of Knowing

In this section, I will look to studies of women's learning as a theoretical lens to inform my views on SI structure and organization. I will first review two theories of women's ways of learning and knowing and then later apply these theories to the SI model and social organization to show parallels between SI's structure and the needs and preferences of women learners.

While SI was not developed to be aligned specifically with the needs of women learners, my experience has shown that women do take advantage of the program more so than men, which implies that something about SI is particularly appealing to women.

In previous sections I have discussed the structure of SI but will reiterate some of the key characteristics that align the program well with the needs of women learners here. The SI program is a cooperative learning environment which provides a non-threatening venue for students to work together to solve problems and gain better understandings of scientific material. It is designed as a social process in which relationships develop between SI participants who are working together in an effort to construct knowledge and solve unique problems.

Women's Ways of Knowing

Belenky, Clinchy, Goldberger, and Tarule (1986) describe cognitive development in women using five types of knowledge or epistemological perspectives. Their theory acknowledges that socio-cultural factors influence cognitive development and that each woman is affected by her own individual experiences. The five perspectives are: silence, received knowing, subjective knowing, procedural knowing, and constructed knowing

Silence is strongly influenced by culture and the actions of others and not all women experience this perspective. Silent women are characterized by accepting the status quo, having a fragile state of mind, being fearful, and being isolated.

Received knowers perceive authorities as the source of an absolute and single truth. Their approach to learning is primarily memorization of information obtained from authorities which can be likened to a traditional instructor-centered approach to science education. Subjective knowers begin to recognize themselves as an authority but they distrust logic, analysis, and abstraction but instead rely on their own intuition. They develop what the authors term "self" and "voice" although their voice tends to be an inner one at this stage. Procedural knowers are characterized by reasoned reflection which can follow two paths: connected knowing and separate knowing. Connected knowers try to understand knowledge from the perspective of others, while separate knowers try to exclude personal beliefs and feelings when analyzing knowledge. Finally, constructed knowers have an integration of “self,” “mind,” and “voice.” They feel like they are part of knowledge and they understand that all knowledge is constructed and that conflict is inevitable. They understand that knowledge is contextually situated and they tend to be articulate and reflective.

Belenky et al. (1986) suggest that the ways of knowing for women are linear with an “ideal” of becoming a constructed knower, with the limitation that not all women become constructed knowers and, when it does occur, it takes years to develop. In terms of the relationship of this theory to postsecondary education, I find it to align nicely with our expectations of science literacy for students. In order to become truly science literate, individuals must develop past the point of being received knowers, which is a category that many women fall into. Unfortunately, the traditional methods of college science teaching have relied on instructor-centered strategies that reinforce single truths and memorizations, and thus perpetuate students as received knowers. Further, some women are particularly fearful of science and/or large lecture classes, leading them to be silent in the lecture class. Providing women with learner-centered environments such as SI may be one way to help students begin to develop their sense of “self,” “mind” and “voice.”

In the next section I will present the epistemological reflection model of Baxter Magolda (1992). This model has many similarities to the Belenky, Clinchy, Goldberger, and Tarule (1996) model in highlighting specific ways in which women know and learn. However, Baxter Magolda also studied men and provides a comparison for different patterns of learning and knowing that are exhibited in each gender. Further, Baxter Magolda's model is specifically focused on college students which is in contrast to the Belenky, Clinchy, Goldberger, and Tarule (1996) model which focuses on women between the ages of 16 and 60. For these reasons, I found it appropriate to investigate the Epistemological Reflection Model as it relates to postsecondary science education.

Epistemological Reflection Model

Baxter Magolda (1992) studied the cognitive development of both women and men, noting similarities and differences in cognitive development related to gender. The epistemological reflection model describes four patterns of knowing that can be related to the reasoning strategies of students - absolute, transitional, independent, and contextual. With the exception of the contextual reasoning strategy, each of these patterns is subdivided into a specific sub-pattern seen in women and a specific sub-pattern seen in men.

The absolute pattern of knowing, commonly seen with college freshmen, is characterized by assuming that knowledge is certain and is only possessed by authorities. Students correlate learning with the collection of materials and facts in class. For women, a receiving sub-pattern was recognized while men displayed a mastery sub-pattern. Women in the receiving sub-pattern consider learning to be their responsibility (and not that of authorities) and they rely on peers instead of authority figures for support, whereas the mastery pattern observed in men is associated with accepting a mutual responsibility for learning with authority figures and relying on peers as a means to strengthen one's knowledge base.

Transitional knowing occurs when a student focuses more on the process of learning and recognizes that some knowledge is uncertain. Two sub-patterns emerge with this type of knowing as well. Women have a tendency towards an interpersonal sub-pattern where relationships are important and they rely on their peers to help solve uncertainty. The impersonal sub-pattern is seen more frequently in male students who tend to only work with peers for the purpose of facilitating their own learning.

The majority of knowledge is recognized as uncertain in independent knowing. Students who are independent knowers are capable of thinking on their own with minimal support and expect their instructors to encourage this behavior. They tend to value their own opinions as well as those of others and are less needy of validation by authorities. Again, different sub-patterns of knowing emerged due to gender. The interindividual sub-pattern was observed in the women who value their peers as part of their learning process and feel that differences in knowledge are due to differences in interpretation. They use discussion with others as a means of clarifying their own thinking. Men tend towards the individual sub-pattern where they focus on themselves. Peer exchanges are valued but are not seen as a way to alter one's views. When challenges to their own knowing arise, they tend to retain their own views.

Contextual knowing occurs when independent thinking and critical analysis skills are used. This type of knowing is rarely seen in college students and no patterns of gender difference were noted with this type of knowing. Students who are contextual knowers are able to apply knowledge in context and analyze context before forming opinions.

The Epistemological Reflection Model provides an interesting lens from which to view the role of SI in women's learning. The peer-based SI environment is uniquely structured so that it may concurrently support multiple levels of knowing including the receiving sub-pattern in women who rely on their peers for support and which is a common pattern seen in college students. Additionally, the SI environment provides support for developing transitional and independent knowing by providing an environment that cultivates interpersonal relationships, affords the opportunity for discussion, and provides peer support for the learning process which supports interindividual sub-patterns.

SI as a Method to Increase Women's Success in Science Classes

The literature is not lacking on suggestions for how to help students become more interested and engaged in science classes and large lecture classes. However, the transferability of these strategies to different populations of students, different institutions, different class sizes, and even different disciplines is sometimes questionable. What is lacking in the literature is a generalizable solution to reducing the gender gap in sciences at the college level. By the time women reach college, there are years of this bias to make up for. Entering into science classes can be a very intimidating situation for women. Finding a solution to enhance the achievement and satisfaction of women in science classes at the college level is of the utmost importance.

While there is much to be found in the literature concerning the preferred learning styles of women, it is important to realize that there are different types of women and they identify with and engage in science education differently (Brickhouse et al., 2000) so that no one method is prescriptive for all women. In this section I will briefly review what the literature has said about best practices in science education, particularly for women, with an explanation for how I perceive the SI environment to support the success of women students in science classes. The two themes I will focus on are: the benefits of SI being collaborative and social (as opposed to competitive and impersonal), and the benefits of SI as creating a supportive and non-threatening climate for women.

SI as a collaborative and social environment. The large lecture style used often in college science classes along with the impersonal nature of most introductory science courses can seem hostile to women which leads them to abandon any interest that they might have in science (Seymour & Hewitt, 1997). Several studies have shown class size to be one of the most important factors in student satisfaction and persistence within a science discipline (Meyer, 2002; Salter & Persaud, 2003) and a critical factor in terms of the perceived degree of chilly climate in a classroom (Constantinople et al., 1988). Without the ability to significantly decrease class size, there must be a focus on developing small group, collaborative learning opportunities outside of the classroom. Success, in terms of achievement and satisfaction, has been reported with this approach in several cases (Lawrenz et al., 2005; Norton, Gildensoph, Phillips, & Wygal 1997; Salter & Persaud, 2003). Further, it has been repeatedly shown that women's preferences for learning include social interactions and collaborative learning experiences within small groups (Alexakos & Antoine, 2003; Brickhouse et al., 2000; Seymour & Hewitt, 1997) as well as peer support (Hanson, 1996; Kahveci, 2006) for learning. Cooperative learning environments provide these preferred characteristics with the additional benefit of tending to increase self-esteem for women (Alexakos & Antoine, 2003; Debacker & Nelson, 2000). Additionally, women respond more positively towards people they interact with as opposed to abstract instruction (Oakes, 1990), so making social connections is critical towards developing a positive attitude towards learning science.

In her ethnographic study of science students, Olitsky (2007) looked at interaction rituals (IRs) that occurred within an eighth grade science class. The IRs were defined as "solidarity-building interactions that can instill a sense of group membership and promote sustained interest" (p. 53). The IRs were designed as low-risk collaborations that allowed for social interaction while challenging the students with specific activities. It was concluded that successful IRs "fostered student engagement with topics that may not have previously held interest and can contribute to student support of peers' learning" (p. 33). Based on my experience, while not exactly the same as IRs, I find that SI sessions have many similarities to the IRs described in Olitsky's study. The SI sessions are designed to be collaborative, allowing for social interactions. Additionally, many SI sessions (including my own) introduce unique problems for students to tackle in their sessions providing a challenge for students in a low stakes setting.

SI as a supportive and non-threatening environment for women. We know that women tend to prefer learning experiences that de-emphasize competition (Alexakos & Antoine, 2003; Rosser, 1997; Seymour & Hewitt, 1997) and provide encouragement from their instructors and their peers (Oakes, 1990) which can lead to an increase in a sense of belonging within the learning community (Alexakos & Antoine, 2003). Learning experiences that can support these preferences may afford women a greater opportunity for success in science classes.

Tindall and Hamil (1994) made several suggestions for how to decrease the gender gap in science. One of their suggestions was to promote an environment of self confidence and success by providing praise and feedback to students. Based on my experience with SI, this sort of positive reinforcement occurs in a well executed SI session and female students in particular seem to be drawn to this environment as compared to the typically competitive environment of most large science lecture classes. Seymour (1995a) asserts that the "learning environment in which many women feel most comfortable—particularly those which are interactive, cooperative, experiential, and learner-focused—are also congenial to many young men" (p. 470). While it is important for the SI environment to beneficial to all students, including men, perhaps it is more meaningful to females who typically have not been afforded these experiences in their past science classes. Historically, girls have assumed a passive role and are less likely to participate in science classes since they are not used to being treated as an equal participant as compared to boys (Mewborn, 1999). In a large lecture setting it is no surprise that women feel less than comfortable. Gaining confidence in their abilities can go a long way towards ultimate personal and academic success in the class.

Additionally, the SI leader can become a very important part of the women's experience and development in SI. The leader is a model student who is a non-threatening peer who supports the students. In my own experience, the leader is typically a female student. Often, the leader is a student who was a non-science major and took the associated classes, but later changed their major to biology. The students attending SI can usually identify with the leader as someone like them who has had similar experiences and understands what they are experiencing in the class. The leader can end up serving as a mentor, friend, and cheerleader for the students. While this mentoring is not formal, it can have a major impact on women. Downing, Crosby, and Blake-Beard (2005) contend that the mentors women encounter during college are more important than mentors encountered at earlier points in education. The type of informal mentoring provided by SI may help women become more confident in their science abilities.

Summary

The structure of SI aligns well with what the literature touts to be environments where women learn best. However, the evidence provided above is largely based on theoretical alignments between what I know about the structure of SI at my institution and what the literature says are effective learning environments for women. I do know that more women than men at my institution take advantage of and benefit from the SI program (Warner, 2005). However, the SI literature is largely silent on why and in what ways the program benefits women. Empirical studies are needed to investigate the meanings SI holds for women who regularly participate in the program. This may lead to a more robust understanding of why women attend SI and uncover perceived benefits that may not have been previously considered. In this way, my theoretical arguments about the alignments of SI with women's learning preferences will be empirically supported or refuted. In the next section I will introduce the concept of identity as an analytical lens for looking more closely at the meanings of SI for women who regularly participate in the program and how this experience might affect their perceptions of themselves as a "science person."

Identity as a Productive Analytic Lens

Most studies of SI are about measurable inputs and outputs. Students who attend SI regularly (input) tend to achieve at higher rates, as measured by grades, (output) than those who do not. As I argued earlier, previous studies about SI, then, have treated SI like a "black box" that mysteriously produced impressive results in terms of student achievement. My goal in this study was to examine more closely the black box in an effort to uncover some specific affordances SI provides for women's growing interest, confidence, competence, and achievement in science.

I chose to use identity as a central analytic construct because it "serves as a pivot between the social and the individual, so that each can be talked about in terms of the other" (Wenger, 1998, p. 174). In other words, I did not simply look at how individual women who participated regularly in SI define their identities (an output). I considered how their perceptions of themselves as "science people" are, in part, inextricably connected to their SI experiences and the meanings they attributed to those experiences. In examining this interplay between the social and individual, I examined the affordances of SI in terms of women's identity.

What is it about SI that enabled these women to define themselves in ways they had not previously? To pursue scientific interests they may have been previously squelched throughout their middle- and high school science educations? To develop a confidence and competence in science that they did not know was possible? Using the concept of identity to frame my study is a way to provide a holistic view of what SI affords for women students which has not previously been investigated.

I will borrow from the three rationales proposed by Carlone and Johnson (2007) for using identity as a lens to view science teaching and learning. First, Carlone and Johnson propose that identity can be used to inquire about how students perceive science and the kinds of students either supported or marginalized by science education. Based on my argument above, the literature is quite clear that traditional, large lecture classes do not promote science identities that are very widely appealing to women (or to many students in general). However, it is worth exploring in what ways SI promotes (or does not promote) a different meaning of science and "good" science student than their large lecture classes.

Second, Carlone and Johnson (2007) propose that studying identity can lead to novel ways of viewing the process of learning and how students become enculturated into scientific communities. Using the identity lens might provide a glimpse of clarity on how women who are regular SI participants and have had a change in their science interests, come to feel like they might be able to become a part of a scientific community. Hearing women's perspectives on their SI experiences may provide some understanding of how women learn to affiliate with (or be alienated from) science which, for some women, may lead them to pursue further scientific interests and perhaps a career in science.

Finally, Carlone and Johnson (2007) argue that the identity lens allows for the discovery of new perspectives that may help explicate why some students identify with science (or not) which can help in the development of reformed science education and support programs. Essentially, the identity lens “aids in the quest for a more equitable science education” (Carlone & Johnson, 2007, p. 6).

Understanding the factors that contribute to the development of science identities has major implications for science education reform. Gaining insights to the specific aspects of SI, as explained by women who have experienced the program, is an important first step in developing or modifying postsecondary programs to support science identities as opposed to extinguishing them and driving women away from science.

Theories of Identity

Because the concept of core identity formation is well beyond the scope of this project, it will not be discussed here. Instead, I will present a brief overview of theories that helped me operationalize the concept for the purposes of this study.

The term “identity” can be used in many ways to convey multiple meanings depending on the context. Vygotsky did not use the term identity, but some of his work can be interpreted as such. He suggested that sociocultural processes are the primary influences on identity development in individuals (Vygotsky, 1978). Sarup (1996) provides a definition of identity that considers sociocultural factors that I find particularly appropriate for my study: “Identity is a construction, a consequence of a process of interaction between people, institutions, and practices” (p. 11).

The development of specific types of identity has often been likened to becoming a certain “type” of person (Gee, 2000; Carlone & Johnson, 2007) —in my case I am interested in how women define themselves (or not) as “science people.” Becoming a certain type of person is not just about how individuals perceive themselves but also about how others perceive the individual. Carlone and Johnson (2007) explain that in order to become a certain type of person one “talks, thinks, uses tools, values, acts, and interacts in ways that are recognizable to others” (p. 8). In the next section, I will more fully investigate theories that explain how individuals might come to recognize themselves (and get recognized by others) as a certain “type” of person. Following, I will discuss the current literature related to science identity.

I have elected to use the work of James Paul Gee to inform my perspectives on identity. Gee’s theory (2000) is focused on identity as it relates to one’s performance in society and the kind of person one sees themselves as and is recognized as by others. Gee (2000) defines identity in general as “being recognized as a certain ‘kind of person’ in a given context” (p. 99). Gee suggests that all people have core identities but that they may have multiple other identities that can be connected to their performance in society. In order to be identified as a certain “kind of person” the importance of others cannot be ignored as they must be able to recognize criteria associated with being that type of person. For example, Brown (2004) describes a situation where a person is identified as being “funny.” However, this identity is largely contextual in that the individual must perform practices or engage in activities, in this case doing things that are humorous, that display that identity to other people. In other words, in order to be “funny,” other people must recognize you in that way. Looking at identity from this angle highlights how identity can be constructed in particular contexts, at particular times, and may vary in different situations at different times.

Science Identity

In this study, I examined women's discipline specific identities—that is the identities that cue their affiliation (or not) with science. Following other science education scholars who study identity (Brown, 2004; Brown et al., 2005; Carlone, 2003, 2004; Carlone & Johnson, 2007; Hughes, 2001; Reveles et al., 2004), I call this "science identity." The issues related to science identity formation become exceptionally complicated and difficult to define in some cases. Gender, ability, ethnicity, socioeconomic status, culture, institutions, and society can all have a role in the development of identities. To further complicate issues, students can develop multiple identities (e.g. academic identities, social identities, ethnic identities, and gender identities), some of which can influence the development of others. In terms of science identity, there is no one specific type, as there appear to be several trajectories a student can follow in becoming a science person (Carlone & Johnson, 2007).

For the purposes of informing my research, I use a sociocultural perspective of identity (Gee, 1999, 2000) that assumes that identity emerges through participation in learning environments that promote greater access to science's discursive practices, such as being able to use relevant science talk. Below, I discuss what I mean by discursive identity and its relationship to science identity, followed by a discussion of learning environments that have the potential to promote access to discursive and science identities.

Discursive Identity and the Learning Environment

Discursive identity (D-identity), as proposed by Gee, has been suggested as being of particular importance for the development of science identity as the discourses selected by an individual can serve as "ways of being certain kinds of people" (Gee, 2000, p. 110). Brown (2004) describes discursive identity as a method by which "speakers select genres of discourse with the knowledge (tacit or implicit) that others will interpret their discourse as an artifact of their cultural membership" (p. 813). It has been suggested that to foster the development of science identity there must be the development and use of dense science discourse (Brown, 2004; Brown et al., 2005; Hughes, 2001); therefore, classroom practices that encourage the use of science discourses may affect the development of science identity in students. When students voluntarily elect to use science discourses they are, knowingly or unknowingly, displaying their science identity which can be recognized by others. Brown (2004) states

> as we develop an understanding (tacit or implicit) of how discourse provides us with the power to become certain types of people, individual agency provides us with the power to select discourses to communicate our . . . identity. (p. 813)

In a study involving African American fifth grade students, Brown et al. (2005) suggested that the discourse and experiences in the science classroom are important factors in determining how teachers perceive students, how students perceive teachers, and how students perceive each other. Students in this study who were open to the use of scientific discourse were more likely to actively engage and participate in science which may ultimately provide a positive influence on their development of a science identity. Hughes (2001) came to a similar conclusion in that the use of classroom practices that encourage the use of scientific discourse make it more likely for students to develop science identities in high school physics classes.

I have discussed discourse as an important variable for the development of science identities, but the specific types of discourse engaged in by students can be further divided into additional categories. In an ethnographic study of minority high school students, Brown (2004) observed four types of identifiable discursive identities. Students labeled as Opposition Status did not use science discourse at all while students in Maintenance Status had demonstrated their abilities with science discourse, but remained committed to their normal discourse. Incorporation Status occurred when a student made active attempts to make science discourse part of their normal discourse. Finally, Proficiency Status occurred when a student demonstrated fluency in science discourse. Only as students progressed with their discourse status, was a science identity likely to develop. Brown (2004) suggests that, to foster progression in discourse status, educators should use practices that scaffold students as they develop science literacy and scientific discursive abilities. Perhaps the SI environment is an appropriate setting that allows students to practice science discourse and become more comfortable with science's discursive practices.

The use of cooperative and constructivist classroom strategies that encourage the use of science discourse has also been promoted as an influence into the development of science identities at a variety of educational levels. Reveles et al. (2004) looked at science identity formation in third and fourth graders and reported that there is a "co-development" of science identity along with academic identity and that one is dependent on the other. In order to encourage this co-development, the authors suggest that science learning needs to be structured in a way that allows students to be inducted into the culture of science. With these realizations and techniques, students may be able to develop and construct their own understanding of science which is a critical factor in the development of science identities. At the high school level, Hughes (2001) concluded that use of more constructivist and socially relevant practices make it more likely for students to develop science identities. Brown (2004) also notes a co-development of academic and science identities and suggests that educators use constructivist practices that scaffold students as they develop science literacy and scientific discursive abilities.

Ties to Science Education

There seems to be agreement in the literature that students need to have the opportunity to frequently use science discourse, or science talk, to become comfortable with the language of science and to develop science literacy. The performance of this science talk affords students the opportunity to enhance their academic identities in addition to allowing them access to their science identities (Brown, 2004). Methods such as Brown's (2004) Directed Discourse Approach to Science Instruction may support the development of science literacy and identities in students. In this learning strategy, Pre-Assessment Instruction is the first step and it is designed to let students and teachers gain insight into what students do, or do not, understand about concepts. Students are given the opportunity to talk about concepts in a low-risk setting in any way they see fit. Next, the Content Construction stage begins where the instructor introduces concepts using activities that lack extraneous technical language. The third step, Introduction to Discourse, gradually introduces students to specific language that relates to the concept and students are provided with the opportunity to test out their science discourse. Finally, Scaffolding occurs where students are allowed to write or orally explain concepts using their newly developed science discourse. I find this approach to be particularly relevant to non-majors college students who often feel put off by being thrown into a course laden with dense science discourse that is unfamiliar to them. Easing the students into the use of science talk by modeling it and providing support as students test out their use of the language could be an excellent method for supporting students who are learning to engage with science discourse.

Ways in which SI might support science identities. The SI environment provides an opportunity to allow students to use science talk in a low-stakes setting. Because students work in cooperative groups to solve new problems, often resulting in constructivist learning, they are, to some degree, obligated to attempt to incorporate science discourse into their explanations. Coupling the opportunity for the meaningful use of science discourse with a collaborative learning environment seems well aligned with what the literature suggests as two important influences on academic and science identities. This may provide some insight into the power of the SI setting and how it may have some influence in allowing certain students the agency to become “science people.”

The use of science talk in a setting such as SI may afford students the opportunity to access both academic and science identities that were previously inaccessible to them.

The Role of Gender in Science Identity

While there are a few models of generalized science identity development, several studies have provided particular attention to how science identities may develop in girls. The models of science identity formation in girls focus on three themes: how girls may feel marginalized by school culture, how the perception of the nature of science may be unattractive to girls, and how the development (or lack thereof) of science identity in girls may be confounded by the development of good student identities.

The influence of school culture. Brickhouse and Potter (2001) studied science identity formation in two high school girls followed over a period of three years. The authors defined identity in two ways for this study. First, identity was described as "one's understanding of herself in a relationship to both her past and potential future" (p. 966). A secondary description was that "identity refers to ways in which one participates in the world and the ways in which others interpret that participation" (p. 966). In this study, the authors found that if a girl felt marginalized, she may be unlikely to develop a science identity, even if she has science potential. The authors contend that school culture tends to exaggerate differences between students, making it more likely for many students to feel marginalized. Students who fit into the model of an ideal student receive more advantages in school, making it more likely for them to develop certain types of identities. Brickhouse and Potter (2001) conclude that individuals do have some control over the development of their identities, however, there are constraints imposed by power relationships and culture that limit the options for which certain sorts of identities can be developed. The ultimate development of identity tends to reconstruct historical social and class relationships. So, for example, the kinds of students who historically choose to pursue science careers (e.g., white males from upper-middle class backgrounds) are the same kinds of students who will continue to pursue science careers in the future, effectively feeding the reproduction of the discipline. The authors conclude by advocating for school reform and better teacher education that will minimize differences in schools and perhaps expand the number of viable choices girls have as they develop their identities.

The influence of the nature and perception of science as a discipline. In a study of African American girls in the seventh and eighth grades, Brickhouse et al. (2000) found that while the girls in their study had similar backgrounds such as family structure, socioeconomic status, and ethnicity, they reacted very differently to their science experiences. The authors speculate that because of the masculine nature of science, it can be difficult for girls to develop generalized identities that are compatible with science. These identities are not singular or stable and are shaped by a variety of influences including teachers' responses to them. Further, it was found that the perception of the traditional structure of science classes was not well received by girls and may be a contributing factor to explain why some girls do not develop science identities.

Looking towards the role that teachers and reformed science can play in the development of science identity, Carlone (2004) studied girls participating in an Active Physics class at the high school level. While it was expected that this alternative form of physics might foster new meanings of science and science identity development in girls, this was not the case. Carlone found that this alternative form of teaching physics may not necessarily be more interesting for girls, that they resisted meanings that were different from norms, and that classroom practices may have given girls the impression that science is difficult and hierarchical.

A second ethnographic study by Carlone (2003) examined girls' participation in a traditional physics class (at the same high school where the Active Physics study took place). Her findings in this study suggest that the classroom practices of traditional physics classes tend to reproduce prototypical meanings of science (e.g., scientific knowledge as authoritative and absolute) which the girls in the study identified with. While the girls in her study embraced and enjoyed the class, not one of them reported any inclinations to further pursue science or showed any evidence of developing a science identity.

The influence of a "good student" identity. Several studies have shown that the development of a science identity can be entwined or confused with a "good student" identity. In Carlone's (2004) study of Active Physics, the girls in the study all showed a preference for maintaining a "good student" identity as opposed to a science identity. In Carlone's earlier study of traditional physics classes (2003), this ability to access good student identities was one reason that girls tended to identify with and prefer traditional physics classes. Further, the girls seemed to see the two as not being compatible with each other and they tended to view physics as serving a singular purpose – polishing their transcripts and college applications. Carlone (2004) theorizes that the girls' perception of science identities was that they were "alienating, inaccessible, and/or uninteresting for girls" (p. 405). Brickhouse et al. (2000) have also suggested that, for some students, being a good science student is merely a result of being a good student in all subjects and not necessarily as the result of a particular inclination towards science. Additionally, some girls with promising science identities were not recognized as such because their academic identities were not as strong as the girls identified as having good student identities.

Defining Science Identity

The literature does an excellent job at demonstrating the complex nature of identity and science identity formation. There are so many factors (discourse, learning strategies, social and cultural settings, perceptions of science, and co-development of other types of identity) involved with identity development that it is hard to get a clear understanding of what the most important variables might be. Carlone and Johnson's (2007) research included a long-term ethnographic study of fifteen women of color who chose to pursue a college major and career in science. They were followed throughout college and for six years after college to study the development and sustainability of their science identities. Carlone and Johnson (2007) describe a student with a strong science identity by stating:

> She is competent; she demonstrates meaningful knowledge and understanding of scientific content and is motivated to understand the world scientifically. She also has the requisite skills to perform for others her competence with scientific practices. Further, she recognizes herself, and gets recognized by others, as a "science person." (p. 7)

Based on this description of a science person, I will define four features that are critical to my study in terms of how I recognized science identity when I saw it. Those features included a student who has: (a) displayed a strong interest in science, (b) demonstrated competence in science, (c) a recognition of herself as a science person, and (d) been recognized by meaningful others as a science person. Figure 1 illustrates how I conceptualized the influences on science identity for this study.

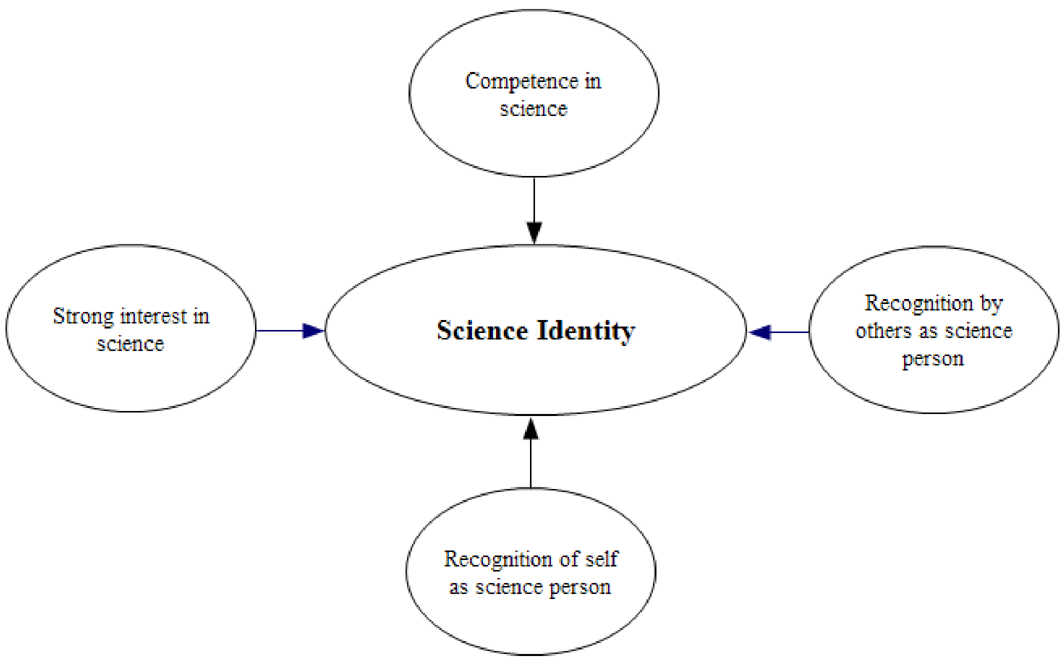

Figure 1. ***Science Identity Model***

In my study, I examined science identity as it related to women who self-identified with a strong science interest making this feature easy to recognize. As for competence, this often is measured by grades. However, I argue that the SI environment might provide a broader and more situational definition of competence. While a student might have difficulty in displaying their competence on high stakes exams in class, they may be able to display competence in alternative ways in the smaller SI environment.

Recognition is another central piece of several definitions of identity (Carlone & Johnson, 2007; Gee, 2000) including my own. Carlone and Johnson (2007) describe recognition as the most critical factor in how science identity develops as “one cannot pull off being a particular kind of person unless she makes visible to (performs for) others her competence in relevant practices, and, in response, others recognize her performance as credible” (p. 8). Not only does a student need to recognize herself as a science person, but she must perform relevant practices (such as the use of science talk) so that others can recognize her as a science person. While a lecture class of 200 students typically does not afford students the opportunity to engage in science talk and be recognized as science people, it is possible that the small group setting of SI might make it easier to be recognized as a science person. In SI, not only can a student use science talk to cue others to her science identity, but she can engage in problem solving activities and the scaffolding of less scientifically inclined students which may help her to recognize herself as a science person.

While not widely established in the literature, recognition appears to be an important factor in the development and support of science identities in women (Carlone & Johnson, 2007). I find that it is particularly important for science educators to be aware of how their recognition, or lack thereof, might influence their students’ science identities. In preliminary interviews I conducted with my female students who have changed to either a biology major, biology minor, or biology focus within education after taking non-majors biology and participating in SI, recognition was found to be a recurring theme related to their interest in science (Warner, 2007). Each of the women had a story of a particularly memorable occasion where they were positively recognized by a family member, a teacher, a peer, or themselves. Further, they all came to eventually recognize themselves as a science person. I theorize that, in part, the SI climate provided a local setting where women could gain recognition from their peers, their SI leader, and themselves. Because the previous science experiences of many women has led them to embrace prototypical meanings of science and not view themselves as a "science person" (Carlone, 2003), it is critical to provide women with options such as SI which allow the opportunity to break away from this thinking and afford them the agency to perhaps consider themselves as a potential science person.

Summary

The development of generalized identities and science identities is a complex process that happens over the course of many years and many experiences. It is influenced by many factors such as gender, ethnicity, ability, class, and culture and perhaps others that have yet to be identified. Identities fall into several categories and an individual can have multiple identities all of which may influence whether a student develops a science identity, of which there can be several types. Research into science identity indicates that, to some extent, school science experiences can influence whether a science identity develops or not. School science experiences that allow students to develop their own meanings of science, engage in culturally relevant science activities, allow students to engage in meaningful scientific discourse, and encourage recognition of students may encourage the development and continued support of science identities. It is suspected that the nature of SI sessions tends to provide some of the experiences that assist students in re-discovering and sustaining their science identities. The elements of SI that may facilitate access to science identities are presented in Figure 2.

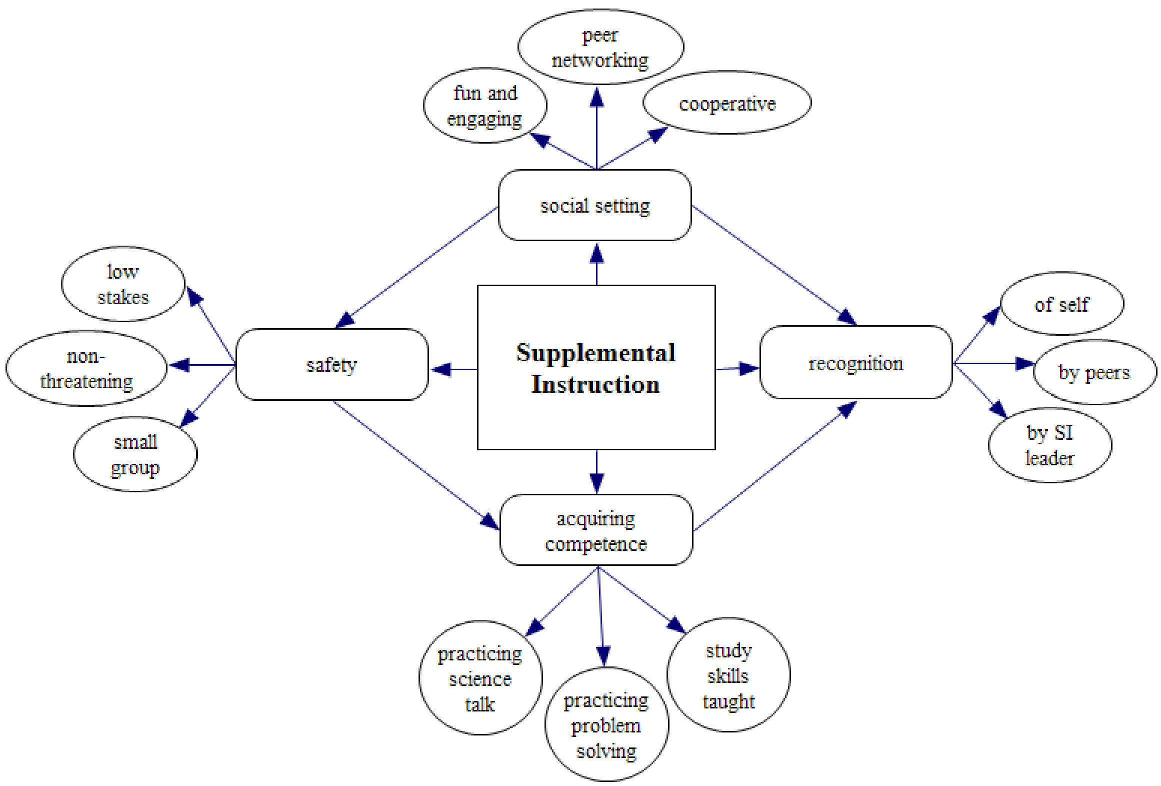

Figure 2. ***The Potential Influences of SI on Science Identity***

Summary of the Chapter

In this chapter I have described various criticisms of the traditional approach to teaching undergraduate science courses along with some suggestions as to how these problems can be effectively improved to best support the achievement and satisfaction of college students. I have described the research that purports that gender bias exists in science and science education to build the argument that we need to improve how science classes are designed, including support programs. Understanding the meanings of the SI program for women who participate regularly may lead to new ways to interpret the SI model and efforts to make the program more accessible to a larger audience of students. The SI model has been reviewed and presented as a potential support program that is particularly well aligned to the needs of women learners. Additionally, it is hypothesized that the experience of non-majors women in SI may, in some way, contribute to the development or rediscovery of science identities and perhaps contributes to a long-term interest and persistence in science.

What is absent from the literature is a more complete understanding of the students attending SI and why they attend. Since women attend SI more frequently than men, the female perspective on SI needs to be fully investigated. Because nearly every college student is required to take general education science courses outside their major, it is particularly important to understand the motivations of students who choose to participate in SI programs associated with general education science courses. Having this information could provide valuable insight as to how SI programs might help decrease the gender gap in postsecondary science courses and increase women's achievement in and attitudes towards science courses. Further, for a small number of women, SI might facilitate a shift in science identities that is important to the women developing a continued interest in science and potentially valuable for increasing the number of women in the science pipeline. The identity lens is particularly useful for studying how

SI might be involved in these shifts as it provides a mechanism for understanding how the individual is formed by their social setting.

CHAPTER III

METHODOLOGY

In this chapter I will review my research questions and reiterate the rationale for each of the questions. I will then describe my research site, research design, types of data collected, and types of analyses performed for the study.

Research Questions

The primary goal of this study was to gain a more complete understanding of the meanings the SI program for non-majors biology holds for two populations of women who used the SI program regularly. These meanings were first investigated in women who regularly participated in SI but had no plans to pursue a science major, minor, or concentration within an education major. Additionally, I investigated how the regular participation of a sub-population of women in SI had an effect on access to their science identities and their persistence in science. This group of women was identified by their declared intent to pursue further science education and potentially to pursue careers in science. The research questions can be summarized as:

1. What meaning does SI hold for women who participate regularly in the program?
   a. Why do women attend SI on a regular basis?
   b. How do women describe the *benefits* (affordances) of SI?
   c. How do women describe the *drawbacks* (constraints) of SI?

d. How do women describe the *learning experiences* in SI?

e. How do women describe *science* as they experience it in SI?

2. What does SI afford in terms of the science identities of successful women who decided to pursue science further after participating regularly in the SI program?

   a. What are the ways the women connect their experiences in SI with their *interest in science*?

   b. What are the ways women connect their experiences in SI with their *scientific competence*?

   c. What are the ways women connect their experiences in SI with the ways they *define themselves as science learners/doers*?

   d. What are the ways women connect their experiences in SI with the ways they *feel recognized by others as competent science learners/doers*?

Based on my students' previous successes with SI and the documented skewed gender ratio of regular attendees, it seemed appropriate to look at a population that is typically marginalized in science education. While the literature suggested that SI makes a difference in grades for regular attendees, we do not know what kind of differences it makes for women. It seemed appropriate then, to study women, a population most often alienated by large lecture courses (Seymour & Hewitt, 1997) and a population who was actively taking advantage of the SI program at my institution to find out more about the meanings SI holds for them. By studying the meanings of SI for women who attend regularly, insight could be gained as to how women define the benefits and drawbacks of

SI, as well as how women define and describe science and their science learning experiences in the context of their SI experiences. Understanding the meanings of SI for regular women participants has the potential to enhance the non-majors science experience for the large population of women who take this course.

Previous research would suggest that, perhaps, some women attend SI simply to get better grades, since women and girls are often most concerned about achieving a good student identity as opposed to a science identity (Aikenhead, 2006; Carlone, 2003, 2004). Yet, based on my preliminary research (Warner, 2007), SI seems to have the potential to play some role in transforming women's attitudes about, understandings of, and interest in science. We know a lot about women who chose to switch from science majors to non-science majors (Seymour & Hewitt, 1997) but we know virtually nothing about women who switch from non-science majors to identifying themselves as a science person. This issue will be fully investigated by my second research question.

While much of the science education reform literature focuses on what is wrong with science education, this study of the SI model may provide an example of a best case scenario for students. It has already been established that there are problems with college science education and that there is a large population of students who will take non-majors science courses not because they want to, but because they have to in order to meet institutional requirements. Understanding the impact of SI on achievement for all students, as well as developing a rich understanding of the meanings of the program for women, will contribute additional evidence to support this population and perhaps provide them with a higher level of achievement, success, and satisfaction with their science courses.

Research Site

The research was conducted at a large University in the Southeastern United States which offers multiple sections of biology for non-science majors each semester. This course satisfies general education requirements at my institution which stipulate that all students must take a life science course. The enrollment of the University is about 23,000 total students. In addition to this university site having a large population of non-majors biology students as well as an SI program that is well established, I also have insider status at the institution. I have been employed by the Biology Department since 1994 and have been on the faculty since the spring semester of 1998. I have personally taught 41 sections of biology for non-majors and have worked with the director of our SI program closely for many years. Prior to considering doctoral studies, I was actively involved in collecting data and performing informal analyses of the effectiveness of SI for my courses. Because I was granted open access to any data I needed from my institutions SI program, and had excellent working relationships with many people involved with SI, this seemed like the most appropriate site to study. In order to truly understand the meaning of SI to women, I felt it was necessary for me to have a closeness to the SI program being studied. My insider status lent itself to getting more candid results from women because of my reputation as a trustworthy instructor, but it also posed some potential validity threats. I discuss those threats and the ways I minimized them at the end of this chapter.

Description of the Student Population

Principles of Biology is a course that meets the science goals of general education requirements at my institution. While it is recommended for students to take general education courses during their freshman and sophomore years, many students put off this course which leads to a significant number of juniors and seniors taking the class. Further, this class is a pre-requisite for certain graduate programs in education and social work which leads to a number of post-baccalaureate students registering for the class. The students taking the class are diverse in terms of their ages, ethnicities, and academic abilities. The enrollment per section is about 200 students and three sections are taught per semester. I personally teach one section per semester while my colleague teaches the remaining two sections. She has adopted my class materials, published notes, grading policies, and assessment options. We share very similar philosophical views on teaching non-majors. Because of this, our students have very similar experiences no matter which instructor they take for the class. In addition, we share SI leaders and SI sessions between our courses. Between the two of us, approximately 1,200 students per year can potentially utilize the SI program for this course.

Description of the SI Program

The SI program has been used at my institution for over 20 years and the success of SI for non-majors biology at my institution has been documented in the literature (Congos et al., 1997). However, the program has not been investigated in the past 11 years and the general education program and non-majors biology course have undergone significant changes since that time.

Each semester, I begin by surveying students to develop a schedule for SI. Each week, eight different sessions are scheduled and any student can chose to attend one or more of these sessions each week. Having eight sessions each week provides nearly all students with at least one session they can fit into their schedule. In Chapter II, I described several modifications I have made to my own SI program in an effort to encourage more students to attend.

Since I have been involved with SI, I have hand-picked my SI leaders each semester. My criteria for selection is that the leader must have been very successful in my class and generally be a model student, being high achieving in all of their classes. I also have a strong preference for SI leaders who were regular participants in SI when they were a student in my class. Additionally, I carefully consider the personalities of each leader to make sure that they will be widely appealing to a diverse audience of students. I look for leaders that are enthusiastic and outgoing that will be able to connect with and engage the students. Once identified, the leaders are trained extensively in the philosophy and methods of SI which is critical to promoting an SI environment that appeals to students and motivates them to succeed. Additionally, the SI leaders have ongoing training throughout their time as an SI leader. They meet with the director of SI and all other SI leaders on campus once a week. Additionally, they meet with me on a weekly basis to address concerns and to develop tactics and activities to approach particular biology topics. There are two leaders every semester which provides students with an option of going to sessions led by the person with whom they feel most comfortable.

Research Design

For this study, I used a mixed methods design to investigate the meanings of SI to women and the role SI may have played in facilitating access to women's science identities. In the next section, I will justify this approach using support from the literature. Following, I will describe the research design and defend how the approach is best suited to answer my research questions.

Justification of the Research Design

The alignment of a researcher with a particular research paradigm tends to drive the types of research questions asked as well as the methodology selected to answer those questions. Positivists and post-positivists tend towards pre-formed hypotheses and quantitative methods, while those operating from constructivist and critical paradigms tend towards qualitative methods and emerging hypotheses although they may select a mixed methods approach (Mertens, 1998). The ontology, or nature of reality, is a philosophical difference that distinguishes the major research paradigms. Mertens (1998) described the major differences between the ontological assumptions of each paradigm. In the positivistic paradigm, the ontological assumption is that there is a single reality which is observable, measurable, and understandable. The ontological assumption of the constructivist paradigm is that there are multiple realities, each of which are socially constructed, while the critical paradigm assumes that there are multiple realities which are influenced by a variety of features including politics, economics, social interactions, and other structural forces. My research questions will be approached from a constructivist perspective, looking towards determining the meanings of SI and the potential roles SI might play in women's science identities.

Creswell (2002) describes quantitative methods as being used appropriately when the goal of the study is to make an assessment of a situation and further explanation for the results is not needed. In my study, quantitative methods are appropriate to document the effectiveness of SI at my institution and analyze survey data from women who were regular SI participants. The qualitative research approach is particularly useful when the researcher is concerned with: meanings drawn by participants, understanding a particular context, identifying unexpected influences, understanding processes that influence particular actions, and developing causal explanations for research questions (Maxwell, 2005). One major advantage of a qualitative design is that it can help to create formative evaluations that can be used to improve practice (Maxwell, 2005). Investigating the meaning of SI for women who regularly participate in the program might similarly inform the reform of non-majors science experiences by providing evidence that the SI model can, in some way, improve non-majors science experiences and perhaps influence the science interest of some women.

Participants and Sample Selection

To answer my research questions, two populations of non-majors students were identified. The purposeful selection (Patton, 1990) used to identify participants in this study has been described as being advantageous as compared to other sampling strategies because it provides data from specific participants that could not be provided as well by other individuals (Maxwell, 2005). In this study, the women who attended SI on a regular basis were better suited to providing thick descriptions of their experiences in SI as compared to women who did not participate on a regular basis. In investigating the meaning of the SI program to regular SI participants (research question one), interviews and surveys were administered to a group (referred to as population one) of women who attended SI regularly (defined as 10 or more weeks during the semester) but have not demonstrated an inclination to continue in science courses. Since this is a non-majors biology course, most women who regularly participated in SI fell into this group. However, there is a small sub-population of women who were regular SI attendees that declared their intent to continue in the biology, even after being declared as a non-science major. In order to determine the influence of SI on their science identities (research question two), a sub-population of non-majors students was identified (referred to as population two). For this portion of the study, all the participants were women who participated in the SI program for biology on a regular basis (defined as 10 or more weeks) during a given semester. Each of these women was identified through their SI participation, above average course grades, and one of the following additional criteria: they changed their major to biology, they changed their minor to biology, or they changed their education concentration to science within an education major.

Data Collection

In the following sections I will explain my methods of data collection as they align to each of the research questions. I will begin by explaining my interview design strategy.

Interview Design

Both of my research questions required interviews as a means of data collection. All interviews were semi-structured and were designed to last about one hour. The interviews were audio taped. Each tape was transcribed and coded for analysis. Each interviewee received a copy of the transcript for member checking and for any necessary clarification or comments. Email interview follow up was used for women who wanted to make additional comments following the interview and to follow the progress of the women.

My selection of interview strategies was aligned with many of Creswell's (2002) suggestions for designing good interviews. I relied heavily on one-on-one interviews which Creswell explains as being good for students who are comfortable with sharing ideas, articulate, and not hesitant to speak. Since I knew the women to be interviewed, I was confident that they fit the criteria suggested by Creswell. I also felt that allowing for individual interviews, as opposed to an alternative format such as a focus group, gave the women the opportunity to speak freely and not be influenced by the responses of other participants.

In developing my interview protocols, I was particular about the design of the questions. As per Creswell's (2002) suggestions, I paid specific attention to the order of and length of the questions. I set up the interview protocols so that the first question was more global in nature (asking the women to reflect on past science experiences) and served as an icebreaker that was easy for participants to talk about. I also kept the number of questions in the protocols to a reasonable length, as it has been suggested by Creswell that protocols that are too lengthy actually provide less opportunity to learn from the participants. Most of my questions were designed to have probes to help delve further into the experiences of the women. Additionally, I took detailed notes during the interviews as well as audio-taping the conversation for later transcription, both of which were suggested by Creswell. I also constructed analytical memos after reviewing my notes and transcripts from each interview. Finally, I followed up on my interviews with email which allowed for the extension and further discussion of themes. Additionally, email was used as a means of member check.

Human Participants Protection

Protection of human participants was completed in accordance with the guidelines for research at the University of North Carolina at Greensboro. Institutional Review Board approval for this study was obtained prior to beginning data collection. There were no identified risks to participants in this study. Survey participants in population one were informed of the purpose of the study as well as their rights as a research subject, including confidentiality and the right to discontinue the survey at any time. The survey was designed so that respondents had to click a link indicating their consent in order to continue to the survey prompts. The women in population two were presented with a consent form by a faculty member unaffiliated with the research project. The participant and the faculty witness both signed the form which was retained by the researcher.

Data Collection for Research Question One

The University Center for Academic Excellence (which houses the SI program on my campus) records information from sign-in sheets used at each SI session and this information was used to identify the women who were regular attendees at SI who were invited to be part of population one.

Interviews. Two women in population one were interviewed to provide insight as to the meanings of the SI program for them which assisted with the survey instrument construction. Specifically, the themes investigated during the interviews included the affordances of SI, the constraints or SI, the descriptions of the SI learning experiences, the descriptions of science, as experienced in SI and why the women attended SI. The interview protocol is attached as Appendix A.

Surveys. As a result of the detailed interviews with two women from population one and years of casual discussions with SI participants, a survey instrument was developed and distributed to all regular women participants of SI. After analysis of the interview transcripts, I had a general idea of some of the meanings (benefits, drawbacks, and descriptions of science) of SI for regularly participating women, but it was necessary to investigate how widely held those meanings were for a larger audience of women. The survey was used as an instrument to triangulate the themes that were elicited in the individual interviews.

The survey instrument is attached as Appendix B. The instrument was modified from existing surveys (Goodenow, 1993), Patterns of Adaptive Learning Scales (Midgley, et al., 2000) and unpublished instruments from Caltech Precollege Science Initiative (CAPSI) and Heidi Carlone. Items from these instruments were modified based on themes that emerged from my interviews with the women in population one as well as my own experiences in talking with active participants in SI over several years. I worked from my model presented in Figure 2 in terms of themes that occurred for regular participants in SI. While my model is designed to explain how SI may potentially facilitate access to science identities, some of the themes from this model also apply to a larger group of women who attend SI regularly (population one) and helped me to further investigate benefits and constraints of SI as well the learning experiences in SI and the definitions of science that result from SI experiences. Those themes were: (a) the climate of SI, (b) the opportunity to increase competence in SI, and (c) the ability to recognize self and be recognized by others in SI. Given this group of themes, I organized several potential prompts in the survey to approach each theme. My goal was to understand the meanings of SI from women's points of views as opposed to testing out a priori hypothetical assumptions.

Each semester between 30 and 50 women are regular participants in SI. The survey was administered to all women who were regular participants in SI during the 2007-2008 academic year via email. Every woman who met the attendance requirements for SI (participation during 10 or more weeks during the semester) was invited to complete the survey.

Quantitative analysis of competence as measured by grades. Women were asked to report on their competence in terms of grades in surveys and interviews. In order to confirm that regular SI attendance did in fact increase competence as measured by grades, actual grades were compared between students who attended SI regularly and those that did not. Two analyses were performed. Mean grades earned between the regular SI attendees as compared to students who did not attend SI were compared using a t test (a = 0.05). The null hypothesis was that there was no significant difference between the two groups and the alternative hypothesis was that there was a significant difference in grades between the two groups. The distributions of grades were also compared between the two groups to determine relatedness. A chi square test was used (p = 0.01) to determine if a relationship existed between the two distributions.

Data Collection for Research Question Two

Through self-identification via conversations or email, women who fit the criteria of being regular SI participants and having a strong science interest were screened for their interest in pursuing additional classes in biology whether that be for the purpose of pursuing a major in biology, a minor in biology, or an education degree with a science concentration. This group of women composed population two.

Interviews. Ten women were interviewed from population two. At the completion of the tenth interview no new themes were emerging and I felt data saturation had been achieved. The purpose of the interviews was to examine how interest in science, competence, recognition of self, and recognition by others was influenced by the SI environment and ultimately contributed to the women's access to their science identities. The interview protocol is attached as Appendix C.

Data Coding and Analysis

In the following data collection matrix (see Table 2), a summary of the questions asked in this project along with the methods used to answer those questions is presented. Further, a brief justification of each method is provided in the matrix.

Table 2

Data Collection Matrix

Questions	**Data collection methods**	**Analyses**	**Justification**
What meaning does SI hold for women who participate regularly in the program?	Interviews with participants (population1) Surveys (population one)	Coded transcripts Descriptive statistics	Interviews are the most appropriate way to allow women to describe their experiences in SI and the meanings they make of those experiences. A survey instrument can test how wide-spread these meanings are in a larger population of women.
How does SI participation influence access to science identities in women who regularly attend?	Interviews with participants (population two)	Coded transcripts	Talking with women who have changed their major, minor, or education focus to biology helped me understand how their experiences in non-majors biology and SI may have contributed to a shift in their science identities

Methods of Survey Data Analysis

All survey data were collected using SurveyMonkey (www.SurveyMonkey.com). The questions were designed such that the participant responded to a series of prompts on a Likert-type scale with the choices being: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). The data from the survey were exported to SPSS for statistical analysis. Descriptive statistics such as mean, standard deviation, confidence intervals, and response frequencies are reported for each prompt. Participants were asked one set of paired questions to report their responses before and after experiencing biology SI. These paired items were analyzed using a paired t-test with an alpha level set at 0.05.

The null hypothesis for this set of questions was that there is no significant difference between the participants' responses to the before and after prompts. The alternative hypothesis was that there will be a significant difference between the participants' responses to the before and after prompts.

Coding and Analysis of Qualitative Data

The analysis of qualitative data began with a preliminary data analysis which consisted of listening to audio taped interviews and reading transcripts. Analytical memos were written during this process in order to elaborate on any insights gained during the data collection and review process. Transcripts were hand coded according to the Creswell (2002) process and eventually collapsed into themes for further analysis. In an attempt to search for the meanings of SI that are carried by women, a domain analysis was conducted as the first stage of semantic structure analysis (Spradley, 1980).

During the initial analysis of the transcribed interviews, several themes became my start codes. For population one (women who attended SI regularly), I looked for themes related to the meanings of SI for these women. I began by coding: (a) benefits (affordances) provided by SI, (b) drawbacks or constraints of SI, (c) descriptions of the learning environment of SI, and (d) descriptions of science. From these start codes, additional codes and sub-codes emerged based on participants' responses.

For population two (women who were regular participants at SI and gained access to science identities), I looked for codes that related to my definition of science identity. This definition was fully developed in Chapter II and included primary influences of: interest in science, competence in science, recognition of self, and recognition by others.

Therefore, the initial start codes I looked for were: (a) strong interest in science, (b) competence in science, (c) recognition of self as a science person, and (d) recognition by meaningful others as a science person. Additional themes were coded as they emerged from the interviews.

Validity Threats

Qualitative research designs can lend themselves to some major validity threats. According to Maxwell (2005), those threats are always recognized and disclosed and can be minimized in a variety of ways. The researcher must understand her bias as well as how reactivity, the influence of the researcher on the participants, might affect the outcome of the study. Maxwell (2005) suggests that the following strategies can be used to minimize validity threats to qualitative research studies. The intensive and long-term nature of most qualitative studies provide the researcher with the ability to collect rich data in the form of detailed transcripts, field notes, and memos. Respondent validation, or member check, is another critical strategy to increase validity. Participants are invited to give feedback on the data to ensure accuracy and to make sure that the researcher is not misinterpreting the data. Triangulation can be used to increase validity by collecting data from several sources, using a variety of methods so as to decrease the biases provided by a single method of data collection

I believe the most serious threat to this project was researcher bias. My close involvement with the SI program, students, and SI leaders as well as the previous success of the program for my students placed me in a position to have a vested interest in the success of the program. I combated this bias by my long-term involvement in the study, taking detailed notes during interviews, writing detailed analytical memos, careful transcription of interviews to allow for the collection of rich data, frequent member checks and triangulation by using multiple methods of data collection (interviews and surveys) and multiple respondents.

A second potential threat was reactivity, or my own influence on the process, during the interviews. Because all of the women interviewed knew me well and had multiple conversations with me outside of class that they had initiated prior to being invited for an interview, I sensed that they were comfortable with me. I made sure that all interviews were conducted at a time at which the women were not enrolled in my class so that they would not feel that I was in a power position over them. In all cases, I found the women to be very candid in their interviews and none of them seemed uncomfortable with the process.

While my position as a researcher with a particular interest in SI does create some validity threats, I feel that my position as an insider with the program and my long-term interest in the program provided me with the ability to gather rich and meaningful data from participants. I have been actively involved with SI since my second semester of teaching. I have a nine year relationship with the director of the SI program at my institution which has provided me with access to a tremendous amount of long-term data concerning the effectiveness of SI at my institution and nationally. Each validity threat was dealt with in a manner to reduce bias and increase internal generalizability. Further, because this study focused on the meanings of SI to women who participated regularly in non-majors biology courses, the results obtained may have some degree of external generalizability to other college settings with large introductory science courses.

CHAPTER IV

RESULTS

The literature on SI consistently reports an increase in course grades for students who utilize SI programs on a regular basis during the course of the semester (Blanc et al., 1983; Collins, 1982; Congos et al., 1997; Congos & Schoeps, 1993; Hodges & White, 2001; Ogden et al., 2003; Shaya et al., 1993; Zaritsky & Toce, 2006). The data collected in this study are in agreement with the literature. However, my primary goal was to determine if regular SI participation provided something more than just a means of increasing grades. I wanted to delve deeper into the SI experience and gain insight into the true meanings of this program for the women who participate on a regular basis by talking directly to the women and learning about the specific details of their experience in non-majors biology.

In this chapter, I will report on specific insights concerning the SI program revealed to me through detailed interview and survey data by the women who regularly attended SI for non-majors biology. The data will be organized into themes and sub-themes to help explain the meanings of the SI program for these women. In addition, potential long-term implications of participation in the SI program including increased scientific literacy, increased appreciation and perceived usefulness of biology, and a continued interest in science will be explored.

A second area to be explored in this chapter is the meanings of the SI program for a unique sub-population of women—those who regularly attended SI as declared non-science majors who later decided to change their college major, minor, or focus within an education major to biology as a result of their experience in non-majors biology and the associated SI program. I will report on the meanings of the SI program for this population and discuss how they compare to the meanings of SI constructed by the first population of women that did not pursue science as a major, minor, or educational focus. Finally, data will be presented to explain how the SI program might help facilitate access to science identities in the women who ultimately express an interest in changing their educational focus to biology.

Research Question One

In this section I will present the results for research question one. This question addressed the meanings of SI for women who participated regularly in the program as non-majors biology students, but did not change their major, minor, or education focus to biology. The research question is as follows:

What meaning does SI hold for women who participate regularly in the program?

a. Why do women attend SI on a regular basis?
b. How do women describe the benefits (affordances) of SI?
c. How do women describe the drawbacks (constraints) of SI?
d. How do women describe the learning experiences in SI?
e. How do women describe science as they experience it in SI?

As described in Chapter III, women in this group will be considered as part of population one. While two detailed, semi-structured interviews were conducted with women from population one in order to assist in the survey instrument design, my goal for this portion of the study was to hear from as many women as possible about their experiences as regular participants in SI. For this reason, a survey seemed to be the most appropriate way to gather a diverse group of perspectives from a large number of women. I wanted to hear from women who had more than just casually experienced the program, so my requirement was that they had participated in SI at least 10 weeks of the semester, having experienced SI over an extended period of time. All women who met the attendance criteria during the 2007-2008 academic year were surveyed soon after their semester had concluded, while their SI experience was still fresh in their memories and details had not been forgotten.

Survey Administration

There were a total of 86 women that met the SI attendance requirements for the academic year; however, eight women were excluded from the survey invitation because they had not completed the course. Four women obtained late withdrawals at the end of the semester for medical or personal reasons and four women received incomplete grades in the course and do not yet have a posted grade. This led to a population of 78 women to which the invitation for the survey was extended. The return rate was 58.97% with a total of 46 surveys completed. Because I designed the survey settings to require completion of all prompts on a particular screen before moving on, every survey was complete and no responses had to be eliminated from the data set. The return rate was a bit lower than I had expected and I speculate on two reasons for that. First, the timing of sending the survey is difficult to navigate. In the interest of getting the invitation out while the SI experience was still fresh, the invitations were delivered during final exam week. Given the stress of this time for students, some responses were likely lost. Reminder emails were sent out one to two weeks later but this often corresponded with semester break when students may not have been checking email or may not have felt compelled to answer school related requests for surveys. Additionally, I did not offer any incentive to the participants (such as being placed in a drawing to win a prize) for completion of the survey.

Typically, surveys are administered to a selected portion of the population of interest which may only be a small number of subjects. In my case, the survey was offered to every participant who met the attendance and course completion requirements. Given that nearly 60% of the entire population responded to the survey combined with the confidence intervals achieved at a 95% confidence level, I am comfortable that the data provide an appropriate representation of population one.

The survey instrument was designed and administered using the SurveyMonkey website (www.SurveyMonkey.com). It is attached as Appendix C. After agreeing with the consent information, respondents were simply given a variety of prompts (organized into themes) to answer on a Likert-type scale with the answer choices being: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). The last question of the survey allowed respondents to provide any detailed comments they would like about their SI experience.

Themes for Population One

My survey instrument was designed to investigate three major themes for the women in population one who participated regularly in SI. These themes emerged from preliminary interview data, my interactions with SI participants over a ten year period, from consulting existing survey instruments (Goodenow, 1993; Midgley, et al., 2000) and unpublished instruments from Caltech Precollege Science Initiative (CAPSI) and Heidi Carlone, and from my conceptual framework which relied heavily on a slightly modified version of the Carlone and Johnson (2007) model for science identity. While I was not looking at the development of science identity *per se* for the women in this population, I found this model to present specific themes that were relevant to the women's perceptions of SI. Those themes were: (a) competence in biology, (b) recognition of science ability by self and by meaningful others, and (c) the climate of SI.

The data for each of these themes will be presented by indicating the mean response for each prompt within the theme including confidence intervals (using a 95% confidence level) as well as the standard deviation. Additionally, the percentage of women agreeing with each prompt (in the column labeled A in each table) will be indicated. This percentage includes women who answered "strongly agreed" or "agreed" to the prompt. The percentage of women who answered "neutral" will be reported in the column labeled N in each table. The percentage of women disagreeing with each prompt (answering "disagree" or "strongly disagree") will be reported in the column labeled as D in each table. It should be noted that several prompts overlap into more than one theme.

Competence in biology. One theme investigated by the survey was how the SI experience might influence competence in biology. While I already knew that regular participants in SI achieved better course grades in biology than non-participants (Warner, 2005), I was interested to see what the women would say about their own perceived competence in biology that was not directly linked to the reporting of a course grade. In this portion of the survey, women were presented with a series of prompts about their perceived competence in biology. The data are listed in Table 3.

Table 3

Reported Competence by SI Participants

Prompt	Sub-Theme	Mean (s)	A	N	D
SI helped me feel better about my ability to be successful in biology.*	perceived influence of SI	4.565 ± 0.173 (0.583)	95.7%	4.3%	0.0%
I would not have done as well in biology had I not attended SI.*	perceived influence of SI	4.413 ± 0.204 (0.686)	89.1%	10.9%	0.0%
I worked hard in biology because I wanted to get better at it	motivation to increase competence	4.304 ± 0.233 (0.785)	87.0%	8.7%	4.3%
I made a good grade in Biology 1110.	grades	4.304 ± 0.257 (0.866)	86.9%	6.5%	6.5%
I made good grades in middle/high school science.	grades	3.935 ± 0.283 (0.952)	67.4%	23.9%	8.7%
I find it fairly easy to explain biology concepts to other people.	confidence in competence	3.478 ± 0.278 (0.937)	63.0%	15.2%	21.7%
I'm comfortable in my ability to solve difficult biology problems.*	confidence in competence	3.435 ± 0.285 (0.958)	56.5%	23.9%	19.6%
Biology seems fairly easy to me.	confidence in competence	3.435 ± 0.317 (1.068)	52.2%	26.1%	21.8%

*notes that this prompt fell into more than one theme

The data collected for the competence theme show some interesting trends and, as expected, a high percentage of women (86.9%) agreed with the statement "I made a good grade in Biology 1110." Because this was self-reported, I wanted to validate this response to the actual grades earned for students that attend SI regularly. Table 4 reports the actual grade distributions obtained as a comparison between students who regularly attended SI and those who did not regularly attend SI during the 2007-2008 academic year. These distributions include all students enrolled in non-majors biology during the academic year. It should be noted that my institution does not utilize a plus / minus grading system so all grades are reported according to the following criteria: A (4.0), B (3.0), C (2.0), D (1.0), and F (0.0).

Table 4

Comparison of Grade Distributions Between Students Who Attended SI Regularly and Those Who Did Not Attend SI Regularly

Without regular SI attendance			**With regular SI attendance**		
Grade	**Frequency**	**Percentage**	**Grade**	**Frequency**	**Percentage**
A (4.0)	71	10.33%	A (4.0)	30	28.30%
B (3.0)	138	20.09%	B (3.0)	35	33.02%
C (2.0)	186	27.07%	C (2.0)	32	30.19%
D (1.0)	139	20.23%	D (1.0)	9	8.49%
F (0.0)	149	21.69%	F (0.0)	0	0.00%
Totals	687			106	

Table 5 shows the descriptive statistics and the result of a t test (a = 0.05) to compare the mean course grade for each group. The null hypothesis that there was no significant difference in means between the groups was rejected and the alternative hypothesis that there is a significant difference in means between groups was accepted.

Table 5

Statistical Comparison of Mean Course Grades Between Students Who Attended SI Regularly and Those Who Did Not Attend SI Regularly

	Without Regular SI Use	With Regular SI Use	t value
Mean grade	1.767	2.811	
Variance	1.642	0.897	
N	687	106	
			10.022*

* denotes statistical significant at a = 0.05

In addition to comparing the mean grade for each group of students, a chi square analysis (seen in Table 6) was performed (p = 0.01, df = 4) to determine if there was a relationship between the grade distributions of students who attended SI regularly versus those that did not. The null hypothesis was that there would be no difference between the two distributions. This hypothesis was rejected and the alternative hypothesis that there is a difference between the distributions was accepted.

The data clearly show that SI participants performed better than those who did not use SI on a regular basis. The t test showed a significant difference in mean grade between the two groups and the chi square test showed that the grade distributions between the two groups were independent of each other.

Table 6

Comparison of Grade Distributions Between Students Who Attended SI Regularly and Those Who Did Not Attend SI Regularly

Grade	Without SI (observed)	Without SI (expected)	With SI (observed)	With SI (expected)	Total
A	**71**	87.43	**30**	13.57	**101**
B	**138**	149.76	**35**	23.24	**173**
C	**186**	188.71	**32**	29.29	**218**
D	**139**	128.12	**9**	19.88	**148**
F	**149**	128.98	**0**	20.02	**149**
Total	**683**		**106**		**789**
				df =4	?^{2} = 60.14*

* denotes significance at p = 0.01

However, I was curious as to whether these students made good grades simply because they had a history of making good grades in science. When prompted with the statement "I made good grades in science in middle/high school" only 67.4% of women agreed. I interpreted this to mean that while some of these women have always felt competent in terms of grades in science, others have not. This could mean that for some women in the study, their first experience with success in a science course came at the college level which is contrary to what might be expected (Seymour & Hewitt, 1997). Additionally, in responding to the statement "I worked hard in biology because I wanted to get better at it," 87.0% of respondents were in agreement. I interpret this to mean that the women were not concerned solely with an outcome in terms of a grade, but that they were also concerned with gaining a real understanding of biology.

While SI participants reported making a good grade in their biology course, it was important to investigate whether the women perceived SI as having a roll in their success. In response to the prompt "I would not have done as well in biology had I not attended SI," 89.1% were in agreement with the statement. Additionally, 95.7% of women agreed with the prompt "SI sessions helped me feel better about my ability to be successful in biology." While there may be many variables that ultimately contribute to a woman's success in non-majors biology, it seems clear that the women themselves attribute much of their success to regular participation in SI.

I did notice an interesting conflict in the data for the competence theme. When asked a direct prompt about grades or success, there was typically a high level of agreement with the prompt. However, when prompted with "Biology seems fairly easy to me," "I'm comfortable in my ability to solve difficult biology problems," and "I find it fairly easy to explain biology concepts to other people," the response means dropped markedly. Having insider knowledge as to how the women are tested in their biology class, there is no doubt that they must be able to solve difficult biology problems in order to achieve a good grade in the class. It seemed curious that the women acknowledged their success in the class but were less likely to report comfort with their abilities, even though those had been clearly demonstrated in the course. Further, since I knew some of these women personally and had listened to them explain biology concepts to others and to me and watched them perform complex problems, I knew their abilities were far above average. I wondered why they downplayed their own abilities. This same issue surfaced when I investigated the recognition theme and I will present my theories on why these women downplay their own abilities in the next section of this chapter.

Overall, women who are regular participants in SI demonstrate their competence in biology but the question is whether this group is any different from the rest of the non-majors population that does not utilize SI. The data provided earlier in Tables 5 and 6 showed statistically significant differences in competence (as measured by grades) for students who attended SI as compared to those that did not attend regularly. Given that the DF rate for this particular biology course was 41.92% during the 2007-2008 academic year, a reported 86.9% of respondents making a good grade in the course is compelling although what constitutes a good grade for one student may be different for another. The evidence provided in Tables 4 and 5 clearly supports the women's assertions that they made good grades in the class as a result of SI participation. The average grade earned by regular SI participants was 2.811 (approaching a B) while the average grade earned by those who were not regular participants in SI was 1.767 (below a C).

Perhaps the most striking evidence is that not one regular SI participant failed the course. For students that do not use SI regularly, the fail rate for the course was 21.6%. In this specific population, SI has shown the ability to drop the typical F rate from 21.6% to 0%. This provides compelling support for the idea that SI truly increases the competence of its participants.

While much of the evidence I have provided on competence comes from grades earned, this was not the only measure of competence gauged by the survey. According to the women, their motivations to attend SI were not solely about earning a good grade in the course (although nearly all of them earned one). Instead, they reported that they really wanted to improve their competence and abilities in biology and they perceived SI as being helpful for doing such.

Recognition of self and by others. The next theme investigated by the survey was recognition. This was defined in terms of how the women felt recognized (or not) by other individuals for their science abilities as well as how they recognized themselves (or not) as science people. I prompted the women with statements about perceived recognition in previous educational experiences as well as during non-majors biology and SI. The prompts and data for this theme can be seen in Table 7.

An interesting trend emerged with the recognition theme. While competence has already been established for this population of women, there was generally a low reported level of recognition for that ability. In particular, the women's recognition of themselves in terms of science ability was quite low. For example, when prompted with "I think of myself as being good in most types of science," only 28.3% of the women agreed. When prompted with "Other students think I am good in science," 52.1% agreed. When prompted with "My teachers in previous science classes thought I was good in science" the rate of agreement increased somewhat to 56.6%. Overall, the trend seems to be that women report their science abilities being recognized by others (such as the SI leader, peers, and teachers) more so than they recognize that ability in themselves, although the reported recognition by others is not particularly compelling.

Table 7

Reported Recognition by SI Participants

Prompt	By	Mean (s)	A	N	D
I felt successful with biology during SI sessions.	self in SI	4.478 ± 0.163 (0.547)	97.8%	2.2%	0.0%
SI sessions helped me feel better about my ability to be successful in biology.*	self in SI	4.565 ± 0.173 (0.583)	95.7%	4.3%	0.0%
I feel confident about my own ability to learn new biology concepts.	self	3.696 ± 0.272 (0.916)	67.4%	21.7%	11.1%
I'm comfortable in my ability to solve difficult biology problems.*	self	3.435 ± 0.284 (0.958)	56.5%	23.9%	19.6%
I think of myself as being good in most types of science.	self	3.065 ± 0.303 (1.020)	28.3%	43.5%	28.2%
In SI, I am recognized for trying hard in biology.	others in SI	3.826 ± 0.237 (0.797)	65.2%	32.6%	2.2%
My teachers in previous science classes thought I was good in science.	others	3.587 ± 0.247 (0.832)	56.6%	37.0%	6.7%
Other students ask for my help to study biology.	others	3.435 ± 0.285 (0.958)	52.2%	30.4%	17.4%
Other students think I am good at science.	others	3.565 ± 0.255 (0.860)	52.1%	41.3%	6.7%

* notes that this prompt fell into more than one theme

I was troubled by the low level of recognition (particularly self recognition) reported by the women in this study. Perhaps the women were not comfortable admitting their science abilities as can be typical for women based on the social construction of gender roles (Brickhouse et al., 2000; Eisenhart & Finkel, 1998; Rosser, 1997). Another possibility is that of stereotype threat in which negative group stereotypes (such as women in science) may have influenced the women's evaluation of their own performance (Steele, 1997). Alternatively, while the women display excellent competency, given their past negative histories with science, they simply may report a low perceived ability in science (Brickhouse et al., 2000; Oakes, 1990; Seymour & Hewitt, 1997). I speculate that this lack of recognition may be one of perhaps many reasons that these women are non-science majors. It is possible that the lack of science recognition that they have for themselves and the lack of reported recognition by others has played a role in their college major choices (Carlone & Johnson, 2007).

The most striking aspect of this section of the survey is the recognition of self that is reported by women when the prompt is linked to SI. Only 28.3% of the women reported thinking of themselves as good in science. However, when prompted with "SI sessions helped me to feel better about my ability to be successful in biology," 95.7% of the women agreed, and when prompted with "I felt successful with biology during SI sessions," 97.8% of the women agreed. To me, this indicates that SI has a role in the confidence women have in their science abilities and their recognition of those abilities.

Climate of SI. The final theme investigated in this portion of the survey was the climate of the SI environment which was reported as a critical piece of the women's satisfaction with SI in preliminary interviews. My conceptual framework, influenced by the Carlone and Johnson (2007) model, heavily informed my construction of the prompts for this theme. In Chapter II, I proposed a model of influences that SI may have on science identity development. While I was not specifically looking for science identity in population one, there are aspects of my model that seemed appropriate to investigate in order to gain a deeper understanding of the climate of SI.

Those sub-themes for this portion of the survey investigated include: safety, support, social setting, and increasing competence. The safety sub-theme was designed to address how comfortable the women felt during SI sessions. I also investigated perceived levels of support in SI, focusing on how women felt supported by others as well as how they felt they supported others. The social setting sub-theme was used to investigate the collaborative nature of SI as well as how enjoyable the women perceived the SI environment to be. Finally, women were asked to report on how the SI environment promoted an increase in their competence. A summary of the prompts and data for this theme and sub-themes is shown in Table 8.

The prompts linked to the safety theme were designed to investigate the comfort level for the participants in the SI environment and whether they were likely to engage and participate in this environment. When prompted with "I felt comfortable during SI sessions" and "In SI it was OK to make mistakes as long as I was learning" there was 100% agreement. Additionally, 97.8% of women reported that they participated in discussions in SI. Given that the women reported feeling comfortable and that making mistakes was acceptable in SI, it seems that the environment does provide a safe and non-threatening place for women to engage with biology.

Table 8

Responses Concerning the Climate of SI

Prompt	Sub-Theme	Mean (s)	A	N	D
In SI, it was okay to make mistakes as long as I was learning.	safety	4.500 ± 0.150 (0.506)	100%	0.0%	0.0%
I felt comfortable during SI sessions.	safety	4.522 ± 0.150 (0.505)	100%	0.0%	0.0%
I participated in discussions during SI.	safety	4.413 ± 0.161 (0.541)	97.8%	2.2%	0.0%
I felt respected during SI sessions.	safety	4.478 ± 0.163 (0.547)	97.8%	2.2%	0.0%
I didn't worry about getting questions wrong in SI sessions.	safety	4.152 ± 0.207 (0.698)	82.6%	17.4%	0.0%
The SI leader helped me during SI sessions.	support	4.543 ± 0.150 (0.504)	100%	0.0%	0.0%
I felt supported during SI sessions.	support	4.326 ± 0.198 (0.644)	91.3%	8.7%	0.0%
Other students helped me during SI sessions.	support	3.957 ± 0.234 (0.789)	80.4%	13.0%	6.5%
I helped other students during SI sessions.	support	3.717 ± 0.285 (0.958)	65.2%	21.7%	13.0%
I was able to interact with other students in the class during SI.	social setting	4.370 ± 0.181 (0.610)	93.5%	6.5%	0.0%
I enjoyed learning biology during SI.	social setting	4.413 ± 0.194 (0.652)	89.1%	10.9%	0.0%
I participated more in SI than I did in lecture class.	social setting	4.282 ± 0.270 (0.911)	80.4%	10.9%	8.7%
SI sessions were fun.	social setting	4.196 ± 0.231 (0.778)	78.2%	21.7%	0.0%
SI sessions provided an efficient way of studying biology.	increasing competence	4.609 ± 0.146 (0.493)	97.8%	2.2%	0.0%
I would not have done as well in biology had I not attended SI.*	increasing competence	4.413 ± 0.204 (0.686)	89.1%	10.9%	0.0%
SI helped teach me how to study biology on my own.	increasing competence	4.043 ± 0.258 (0.868)	73.9%	19.6%	6.5%
I feel like I studied better in SI than I do by myself.	increasing competence	3.956 ± 0.331 (1.114)	71.7%	15.2%	13.0%

* notes that this prompt fell into more than one theme

Because SI is designed as a collaborative learning experience, I wanted to hear from the women concerning the level of support they perceived from each other and from their SI leader during sessions. When prompted with "I felt supported during SI sessions" 91.3% of the women agreed. However, when faced with "I helped other students during SI sessions" the percentage in agreement dropped to 65.2%. I theorize that this is related to the women's tendency to either downplay or fail to recognize their own abilities in biology as was seen in both the competence and recognition themes. Finally, 100% of the women agreed with the statement "The SI leader helped me during SI sessions." In addition, many women made specific comments at the end of their surveys addressing how much their SI leader had supported them during (and after) sessions.

> My SI leader was very fun and explained things creatively. She was willing to go as slow as we needed her too, and she never treated us as lower level students.

> Amy is a great SI leader and always tried to help us understand confusing topics. I could tell she really cared about helping us! She was always willing to stay later to help us if we needed it

> Kayla was an excellent SI leader. She was always prepared and went out of her way to help us understand the concepts. She is the reason I have an A in this class.

The social setting of the SI sessions was also investigated. I was interested to hear how much the women interact with each other and whether they found those interactions during SI to be enjoyable. Based on my 10 years of experience teaching non-majors biology, I find that many non-majors students report studying biology to be drudgery. I was interested to see if the SI environment would help improve attitudes towards learning and studying biology. When prompted with "I enjoyed learning about biology during SI," 89.1% of women were in agreement and when prompted with "SI sessions were fun," 78.2% of women agreed. Perhaps the women saw this sort of environment as a welcomed alternative to the non-social method of studying alone.

Finally, I investigated the women's perceptions on how the climate of SI might influence their competence in biology. In addition to specifically looking at perceived competence, I also saw some of these prompts as investigating an increase in confidence in biology. There was generally a high level of agreement with prompts regarding how SI helped women to learn to study on their own and to become efficient with their studying. Most notably, 89.1% of the women reported "I would not have done as well in biology had I not attended SI." This clearly indicates that the SI environment is conducive to helping women learn and increasing their competence with biology.

Overall, many factors relating to the climate of the SI environment seem to be appealing to the women who attend. Regular participation appears to increase reported competence and confidence in biology. Perhaps this is because the environment is well aligned with what we know about how women learn best. The social and supportive environment provides a safe place for women to work through difficult biology concepts and problems. The women report that they do not hesitate to participate and do not fear being wrong while they are practicing and learning in SI.

Changes in Attitudes and Perceptions as a Result of Non-Majors Biology and SI

I designed one section of the survey to probe women about some of their perceptions about themselves and science. This series of prompts was designed as a pre and post comparison. First, I asked the women to respond to the prompts while thinking about themselves before they took non-majors biology and participated in SI. I then presented the same set of prompts and asked the women to respond based on how they felt after experiencing non-majors biology and SI. The results of this portion of the survey are shown in Tables 9 and 10. Table 9 shows each prompt for this section of the survey along with the mean and variance for the answers provided as women considered themselves before and after their non-majors biology and SI experience. A matched pairs t-test was performed for each prompt and the t value is also located in the table.

Table 9

Comparing Perceptions Before and After Experiencing Non-Majors Biology and SI

Prompt	Before	After	t
In general, I find biology interesting.	mean 3.717 variance 1.141	mean 4.196 variance 0.739	3.093*
I talk to friends and family about biology.	mean 3.239 variance 1.297	mean 3.761 variance 0.986	3.375*
I sometimes read news articles that relate to biology.	mean 3.000 variance 1.289	mean 3.391 variance 1.132	2.716*
I was interested in taking more biology classes.	mean 2.587 variance 1.448	mean 3.326 variance 1.158	5.136*
I felt I would be able to use what I learned in biology after the course was over.	mean 3.783 variance 1.107	mean 4.239 variance 0.675	3.308*

* denotes statistical significance at a = 0.05

Table 10 presents data on the same prompts in a different way. The percentage of women who selected agree (4) or strongly agree (5) for each prompt is indicated for each prompt along with a percent change in mean responses before and after the semester.

Table 10

Respondents Agreeing with Prompts Before and After the Semester

Prompt	Before	After	Percent Change
In general, I found biology interesting.	65.2%	84.8%	+ 19.6%
I talked to friends and family about biology.	56.5%	73.9%	+ 17.4%
I would sometimes read news articles that related to biology.	39.2%	56.6%	+ 17.4%
I was interested in taking more biology classes.	21.7%	45.7%	+ 24.0%
I felt I would be able to use what I learned in biology after the course was over.	73.9%	84.5%	+ 10.6%

Working from the supposition that interest in science typically diminishes in most populations of students over the course of their education, it was surprising to see women's responses when asked the same set of prompts from two different perspectives—thinking about themselves before they came to biology and SI and thinking about themselves after they came to biology and SI. For each of the five prompts, the t values obtained in a matched pairs comparison (between the before and after means for each prompt) show statistical significance at an alpha level of 0.05. The null hypothesis (that there was no significant difference between the before and after means for each prompt) was rejected and the alternative hypothesis (that there is a statistically significant difference between the before and after means of each prompt) is accepted.

As an instructor, it is gratifying to hear the women report an integration of biology into their outside lives. They reported an increase of 17.4% in reading about biology in the news and talking about biology with their friends and family. Their reported level of interest in biology increased as well as their perceived usefulness of biology in their lives. The most compelling response for me was to the prompt “I would be interested in taking more biology classes.” Given that students enrolled in non-majors biology are fulfilling their general education science requirement, they will not ever be required to take another science course. I was pleasantly surprised to see nearly half of the women report that they are interesting in taking another biology course (a 24.0% increase) but wondered if this was something they would act on. In order to satisfy my curiosity, I checked to see how many of these women registered for a second biology class. Because many of these women just concluded their first biology class, some had not yet registered for their fall classes. Further, some reported that they would be taking their next biology class during the spring semester of 2009 because the course they were interested in taking was not offered in the fall semester of 2008. Given that registration data alone were not enough to give a clear indication of the number of women who would in fact take another biology class, I relied on two pieces of information. I looked at the actual enrollment in additional classes and considered women who had specifically come to me to discuss their plans for taking a second biology course during the spring semester of 2009. Given the official registration information as well as the declared intent to register provided by a personal conversation with the students, I found that 42.55% of the women surveyed did act on that intent by either registering for another class or taking steps to be advised on their next biology course. Having evidence that some of the women elected to take additional biology classes that are not required for their major seems to be the ultimate evidence that some of the women had experienced a transformation in their perspectives and attitudes about biology during their time in non-majors biology and SI.

Meanings of the SI Program for Women Who Participated Regularly

In the previous sections I have reported on the trends in the survey data. In this section I will describe how the data answer research question one - What meaning does SI hold for women who participate regularly in the program? Where appropriate, I will provide specific comments from the women in their own voice to explain the meanings of SI for them. All quotes provided in this section were in response to the following prompt at the end of the survey: “Please feel free to write any additional comments you might have about your SI experience here.”

Research question one was designed with five sub-questions: (a) Why do women attend SI on a regular basis?; (b) How do women describe the benefits (affordances) of SI?; (c) How do women describe the drawbacks (constraints) of SI?; (d) How do women describe the learning experiences in SI?; and (e) How do women describe science as they experience it in SI?

The first sub-question to explore is why women chose to attend SI on a regular basis. The data presented thus far provide many reasons that women go to SI. The women want to get better (increase their competence) in biology. They perceived the SI environment as safe, social, and supportive which gave them the ability to practice biology and increase their competence and their confidence in biology. In particular, the role of the SI leader’s support was mentioned in most of the comments provided by the participants. Overall, the SI experience increased their class performance and their attitude about biology. In general, the women report that SI helps them feel better about their science abilities. The following are statements from three different women, in their own words, that describe why they chose to go to SI:

> Without SI I really would have an F in the class. I had an F on my first test and I never went to SI. I started going every week and on my second test i got an A. :) SI really saved my GPA.
>
> I had to withdrawal from biology last semester because I was failing. This semester I was not about to let that happen, so I tried SI out. SI is the only reason why I am passing this semester because it takes the material and breaks it down to where students can understand clearly.
>
> SI was overall a great way for me to boost my confidence about Biology.

In trying to understand the meanings of SI for the women, it was necessary to investigate the benefits and affordances that SI provided for the women. To some degree, there is an overlap between the benefits provided by SI and why women attended. For example, women attended because it increased competence, but increasing competence was also considered a benefit of participation by the women. Women also reported that SI helped them study efficiently, helped them learn to study on their own, and, of course, increased their grades. Following are quotes from five different women about their perceived benefits as regular SI participants:

> I enjoyed the SI sessions, and felt like they were necessary to grasp the concept covered. The information covered during lecture was so fast paced for me, and the SI sessions helped the information "sink in." If I was unable to make an SI session, I felt that I would not do as well with that section on the test

> Supplemental instruction makes life easier on studying and college courses in general.
>
> I really enjoyed that there were a lot of options on when i could attend SI. the different sessions fit well with my schedule and they really helped me understand biological concepts and what i personally needed to focus on more when i was studying for upcoming tests.
>
> SI helped me to do well in the class, without it I would have had a very difficult time.
>
> it helped me understand the things that i didn't get during class because i could ask question one on one until i understood or solved my problem

I also looked for any drawbacks or constraints that the women may have perceived as associated with SI participation. I specifically probed deeply on this issue in my original interviews to see if this was something I should stress on my survey instrument. However, I did not find much evidence to support that the women perceived any drawbacks to SI. There were occasional suggestions in the comment section of the survey about adding additional session times or making the sessions longer, but I did not detect any negative trends about the structure or nature of the sessions in any of the data.

I was particularly intrigued to hear how the women described the learning experiences in SI. The survey data suggest that the women perceive the learning experiences in SI to be helpful in increasing competence, collaborative, safe, and fun. This was reinforced by the following comments:

> Because lecture class was very large, SI provided me the normal classroom experience of having someone there to help work through the questions.
>
> I struggled in biology only because I'm not that great in the subject; not to say it didn't interest me because it did. I came out of the course with a B and I owe alot of that to 1) my professor being so enthusiastic about the subject and finding ways

> to teach to EVERY different learning style of her students and 2) for the SI sessions i participated in. I ABSOLUTELY would tell current bio students to make sure and participate in these sessions. It was a smaller class setting and open to ask questions. I felt much more comfortable in there when I messed up rather than in the lecture. I don't know what kind of grades I would have made if I didn't attend SI regularly. I wouldn't have believed you if you would have told me this at the beginning of bio 1110 but IT WAS FUN!!! I loved learning this stuff... even though it was challenging.
>
> As a child I only attended school half days as I was a highly competitive gymnast. Unfortunately I missed several important classes and never built a foundation for math or science at a young age. Because of this math and science have always been extremely challenging for me. I was extremely nervous about Biology as it was a huge class and I had just transferred from a small University. I attended class every single day (even though it was at 8 am) and at the midterm was making a D. I was extremely upset as I was trying so hard to understand the concepts and thought I was doing all I could. From that point on I attended SI almost every single week, not just for the extra credit point but because it went into great detail about concepts I would have never grasped on my own. I left SI feeling confident about the material, which is something I had never felt before. It was very helpful having the opportunity to ask questions in a small environment. I would have never made it through Biology without having the best professor I have ever had . . .she was always willing to go out of her way to help if I asked for it and explained and broke down concepts better than any professor I have ever had. Most SI leaders were the same way and would also stay after and go over questions one on one which was very helpful. My final grade in Biology was an A, I worked extremely hard for it and couldn't have done it without SI and my professor. Thank you so much!!!

Finally, I wanted to understand how women describe science as they experience it in SI. Because of the relaxed and positive climate of SI, the women seem to develop more positive attitudes about biology, they seem to gain a more realistic understanding of science, more appreciation for the process of science, and develop a long-term interest in biology. The following are quotes from three women describing how they experienced science in SI:

> SI was a wonderful enhancement to Biology 1110. I never thought of myself as a science lover until after I took the class . . . SI and Biology 1110 have opened my eyes to the subject of science (focusing on biology).
>
> SI was great and definitely helped me to earn an A in Bio. (The SI leader) was a great teacher and I will remember a lot of the things she taught me for the rest of my life.
>
> The SI sessions are beneficial. I enjoyed them. I learned in them. We did not just review. The SI leaders required everyone to participate. I wish every class had this opportunity. I would do better in all classes.

There are common themes that emerged repeatedly in the survey data. Women absolutely used SI to increase their competence (and grades) in biology—this was certainly no surprise. While doing this, they increased their confidence in biology, their attitudes about biology, and their enjoyment of biology. They found an environment that was supportive and safe where they could practice difficult biology problems with no fear of being wrong. They met SI leaders who cheered them on and peers who understood them and supported them. The learned that they were capable of being successful in biology, despite what they may have thought about their abilities coming into the course. Most importantly, participation in this program allowed the women to leave their biology class with a positive feeling about biology and perhaps some long-term implications that will be discussed in the next section.

Potential Long-term Meanings of Regular SI Participation

I concluded the survey by presenting the following question to women in order to investigate potential long-term implications of SI for the participants: "After taking Biology 1110 and using SI it is possible for me to:" followed by a list of prompts. The prompts were organized into specific themes to investigate: scientific literacy, long-term engagement with science, the potential for serving as a biology ambassador, and potential pipelines to science and science teaching. The prompts and the women's responses can be seen in Table 11.

Table 11

Potential Long-term Implications of SI Participation

After taking Biology 1110 and using SI it is possible for me to:	Sub-Theme	Mean (s)	A	N	D
Make informed decisions about scientific issues	scientific literacy	4.087 ± 0.164 (0.551)	89.2%	10.9%	0.0%
Use my biology knowledge to solve new problems	scientific literacy	4.000 ± 0.166 (0.558)	84.8%	15.2%	0.0%
Feel comfortable reading about biology in the news	scientific literacy	4.022 ± 0.171 (0.577)	84.8%	15.2%	0.0%
Think scientifically	scientific literacy	4.000 ± 0.177 (0.596)	82.6%	17.4%	0.0%
Use biology in my career	long-term engagement	3.587 ± 0.291 (0.979)	60.8%	26.1%	13.0%
Take more science classes	long-term engagement	3.565 ± 0.291 (0.981)	56.5%	28.3%	15.2%
Be successful in other college science classes	confidence	4.043 ± 0.198 (0.665)	80.4%	19.6%	0.0%
Help other students study biology	ambassador	3.935 ± 0.246 (0.827)	76.1%	17.4%	6.5%
Encourage other students to take biology	ambassador	3.913 ± 0.215 (0.725)	71.8%	26.1%	2.2%
Become an SI leader	pipeline	3.000 ± 0.343 (1.144)	28.2%	39.1%	32.6%
Eventually become a science teacher	pipeline	2.739 ± 0.340 (1.153)	21.7%	41.3%	37.0%

There are several major issues raised by this data. The first is that women report a high level of agreement (82.6-89.2%) with prompts I have categorized as being related to scientific literacy. Since this is a stated goal for so many non-majors science classes, it is gratifying to know that SI participants report that they are capable of thinking scientifically, making informed decisions about science, being able to solve new problems in science, and feeling comfortable reading about science. Based on the description of the SI structure and environment by women, they gained skills that help increase their scientific literacy.

A second theme in this data is that of long-term engagement with science. Some 56.5% of the women reported that they could see themselves taking more science classes and 60.8% saw a role for biology in their careers. I found it quite surprising that so many women saw a potential role of biology in their eventual careers. Further, women reported a confidence in sciences that extends further than just biology with an 80.4% agreement with their ability to "be successful in other college science courses."

I also prompted women about their perceived role as a biology "ambassador." By this, I mean a student who can encourage other students to take biology and help support those students. A question I ask of every student during the first week of the semester is "What sorts of comments have you heard about this class from other students?" Needless to say, some interesting comments always emerge which typically center on concerns that no student could possibly do well in the class, it is too much work, they will not be able to keep up with the pace, and so forth. Having former students who are willing to praise their experiences in biology to their peers along with encouraging potential students to take the course and use SI is a tremendous asset to the reputation of the course and the SI program. Given that students are more likely to take advice from peer ambassadors as opposed to faculty ambassadors, this population of satisfied former students can go a long way to promote a positive attitude towards science and participation in the SI program.

Finally, I investigated two areas which I labeled as "pipeline" for the theme. First, I asked the students if they could see themselves becoming an SI leader. While only 28.2% agreed with that statement, that equates to 13 students (out of 46 surveyed) who are potentially interested in becoming an SI leader and supporting future students. I see this as an excellent pipeline to find future SI leaders who have experienced the program as a student and truly understand its power for regular attendees. In addition, I asked if the women could see themselves becoming a science teacher. The agreement rate was only 21.7%, however, that includes 10 women who agreed with the statement and may be interested in teaching as a career. Knowing the incredible need for good science teachers, this could serve as a previously untapped resource for locating potential new science teachers.

Summary of Research Question One

In my attempt to construct a theory on the meanings women make of their SI experiences, I looked at three specific themes related to SI participation: competence in biology, recognition of self and by others for science ability, and the SI climate. Each of the women displayed a high level of competency in biology that was, at least in part, attributed to regular SI attendance. However, I found that women tended to downplay some aspects of their competence when self reporting and that they generally have a low level of self recognition nor did they have a particularly compelling history of science recognition by others. While the SI experience certainly increases women's performance in terms of grades in biology, it has a dramatic effect on increasing the women's feelings about their abilities to be successful in science and their enjoyment of biology.

In asking women to compare themselves before and after participation in non-majors biology and SI as well as to consider their own potential once the semester was over, it was revealed that regular participation in SI can have an impact on increasing long-term interest in science, the perceived usefulness of biology, scientific literacy, and an integration of biology into everyday life. Additionally, there is potential for a small proportion of these women to have important future roles as SI leaders or as science teachers.

Overall, the women in population one were initially motivated to use SI as a means to increase their performance in biology class and increase their confidence in their ability to be successful in biology. As a result of attending SI, they found a supportive, social, and safe environment to practice biology and increase their understanding, interest in, and appreciation of biology. They left non-majors biology with a positive attitude about biology and the potential to serve as future ambassadors to other students contemplating taking non-majors biology and participating in the SI program.

Research Question Two

My second research question is an extension of the first. Having explored the meanings of SI to a generalized population of women who attended regularly, I now turned towards investigating the meanings of the SI program to a special population of women (population two) who have taken their interest in science to a new level by transitioning from a declared non-science major to a biology major, biology minor, or science focus within an education major. Research question two is as follows:

> What does SI afford in terms of the science identities of successful women who decided to pursue science further after participating regularly in the SI program?
>
> a. What are the ways the women connect their experiences in SI with their *interest in science*?
> b. What are the ways women connect their experiences in SI with their *scientific competence*?
> c. What are the ways women connect their experiences in SI with the ways they *define themselves as science learners/doers*?
> d. What are the ways women connect their experiences in SI with the ways they *feel recognized by others as competent science learners/doers*?

While switching out of science majors to a non-science major is heavily reported in the literature (Seymour & Hewitt, 1997), this sort of immigration into science at the college level is not documented. Although this population of women is not large, it is valuable as a potential untapped pipeline into science. While the goal is certainly not to recruit the conversions of non-science majors to biology majors, a better understanding this group of women could lead to more appropriate tools and pedagogy to support and encourage those non-majors students that do have the inclination to pursue science. It is critical to determine the affordances provided by SI that facilitate access to science identities for this group of women.

Because this population of women is so unique and previously undetected within the non-majors population, I wanted to gather thick descriptions from them concerning their perspectives on SI. My goal was to talk at length with the women involved to investigate their perspectives on SI and how participation in SI influenced their transition. I will begin this section by reporting on how the women in population two describe their meanings of SI, drawing parallels between this population and population one where possible. I will then investigate how the SI environment may play a role in supporting access to science identities for the women of population two. In particular, I drew on the Carlone and Johnson (2007) model of science identity to look at three major influences on science identities including (a) interest in science, (b) competence in science, and (c) recognition in science by self and of others.

Interview Procedures

All data for research question two are the result of detailed, semi-structured interviews with women who were regular participants in SI during their time in non-majors biology and who later changed their major or minor to biology, or their focus as an education major to biology. The interviews were conducted with 10 women over a two year span between early 2006 and late 2007. Extensive notes were taken during the interviews. Following each interview, analytic memos were written and each audio tape of the interview was transcribed. During data coding and analysis, notes taken during the interviews, analytic memos, and transcripts were consulted. Trends and themes emerging from each interview were provided to the participants for member checking. For the women who were interviewed earlier in this project (during 2006), their continued progress in their coursework and their careers was tracked via additional conversations and email follow-up. This has provided some insight into the longevity of the women's interest in science.

Analysis and Reporting of the Data

Domain analysis was conducted as the first stage of semantic structure analysis (Spradley, 1980) for the interview data. Codes and sub-codes were developed for each domain and transcripts, notes, and analytical memos were reviewed to determine the frequency of each code. I have reported the data according to the frequency with which it was obtained in order to establish the strengths of each trend across the interviews. The frequency count reported refers to the number of women interviewed whose description of their experience fell into that particular code. For example, a frequency count of 10 would indicate that particular code was noted in the interview data for 10 different women. In addition to providing frequency counts for specific codes, I have also tried to provide data in the women's own voice, pulling directly from comments they provided in their interviews.

Meanings of SI for Population Two

In this section I will report on data collected in population two that provides insight as to why these women attended SI and the meanings they attribute to participation in the program. In general, many of the stated reasons for why the women attended SI paralleled those given by population one. The reported reasons can be seen in Table 12.

Table 12

Common Reasons Given for Attending SI

Code	Explanation	Frequency
To make better grades	Student wanted to make a good grade in the course	10
To get better at biology	Student was interested in learning more about biology	9
Practice	Student wanted the opportunity to practice biology and prepare for exams	9
Application	Student enjoyed applying material and felt it was beneficial for them	6
Peer interaction	Student enjoyed working collaboratively with peers in the class	6
Promoted	Former students or instructor promoted the SI program	6
Fear	Student was intimidated by course and needed support	3

When asked why they chose to attend SI, there were a variety of factors that seemed to motivate the women in population two. Some of them were intimidated by the size of the lecture class and were worried that they might not do well or had heard the class was difficult from other students. Not knowing what to expect in the class coupled with their fear was their motivator to attend SI for the first time as evidenced by this comment:

> At the beginning, I had always heard that college biology is so difficult and I think that is kind of the college myth. I was scared and I wanted to do anything I could to . . . help me pull up my grade. In high school everything is group work and in college it is lecture-based so it's at your own risk.

For others, they were confident that they would do well in biology based on prior experience, but they tried SI because they figured it would be some extra practice for them that could only help them. They reported that SI provided them with an efficient way of studying biology.

> I think it helped me study more efficiently. Because studying for biology is, well, I've never studied for a class like biology like I have studied for any other class. Most of the time I just get my book and I'll take notes from the book or go over my lecture notes, re-write them, or make flash cards. That didn't work for this class - learned that around the first test, haha!
>
> It was more of a good way to study instead of, you know, going outside of class. Cause I know once I get out of class that I can get distracted and I don't spend as much time studying for stuff.
>
> I never really studied that way (like in SI) before so it was not just a way of studying biology but a way of studying period.
>
> I feel like I didn't have to do that much outside studying because we went over everything in SI. It really helped me to understand everything.

Additionally, some women tried SI because they reported that there was nothing they would not try in order to be successful in a class. They had histories of extremely impressive performances in all of their classes and they initially attended SI because they wanted to do everything in their power to be successful with the class.

> Well, I'm an overachiever you know, using someone else's terms. I don't think of it that way. I just truly don't. If somebody says to me 'well what's wrong with a B?' well, what's wrong with an A? . . . My mom said I was like that in the first grade.
>
> I will do anything that is going to help me learn the material better.

Others decided to try SI because their instructor had promoted it so heavily or they had gotten a recommendation from a student who had previously taken the class and used SI. All of the women stated that part of their motivation to attend SI for the first time was to see if participation in SI would help them to be successful in their biology course. These were the initial motivators that got the women to attend for the first time but once they were there, they all recognized that the program would be helpful to them and decided to continue attending during the semester. Further, once they realized that they were doing well in the class (after the first exam), they attributed this success to participation in SI and this provided more positive reinforcement for them to continue attending.

Descriptions of the SI Environment

In my interviews with the women, I asked them to describe the typical climate of an SI session, how they personally participated in the sessions, and how their participation in SI helped them with biology class and science in general. The three sub-themes that emerged from this data were: (a) support provided in SI to others and by others, (b) safety of the SI environment, and (c) the benefits afforded by the social nature of the SI sessions. Some of the major sub-themes are described in Table 13.

When asked to describe their participation in SI, most of the women described a highly interactive experience which involved a great deal of question asking and answering. They reported that the small group environment was conducive to question asking and peer interaction which helped them to grasp and understand problems.

> I thought that in a small group environment like that (SI) I would get to hear different questions that people were having, like things that they were having a hard time understanding and that would help me.

> I liked that there were additional types of questions that made us think about it (biology). And in SI we would talk about why something didn't work or wrong

answers, and why they might be the right answer. So we kind of dissected the different areas.

Table 13

Descriptions of the SI Environment

Codes	Explanation	Frequency
Support of others		
Studying	Student reports that the SI environment supported good study habits	10
Motivation	Support in SI helped student be motivated to practice biology	7
Peers	Student reports that they often helped their SI peers	5
Support by others		
SI Leader	Student felt supported by SI leader	9
Peers	Student felt supported by peers	5
Safety		
Comfortable	Student felt comfortable in the SI session	10
Non-threatening	Environment was not intimidating	10
Mistakes allowed	Student reports that it was OK to be "wrong" in SI	9
Small	The small number of participants was perceived as beneficial	8
Low-stakes	Because SI was not graded, student was more likely to participate	8
Social setting		
Peer interactions	Student was able to interact frequently with peers during SI sessions	8
Social networking	Student was able to meet other students from the class (that they did not know prior to SI)	6
Fun	Student reports that participation in SI sessions was fun	6
Interactions extended	Student met outside of SI sessions to study with their SI peers	3

The women also indicated that they were able to ask numerous questions because the environment was not intimidating to them and felt safe and non-threatening. It provided a comfort level that was much different from what they typically experienced in large lecture courses. Many of them said that they asked questions in SI that they would never feel comfortable asking in class and that they were not worried about being "wrong."

> At every SI I would always ask questions. I probably got on her (the SI leader's) nerves because I asked questions so much!
>
> All the SI sessions I've ever had have been really relaxed about things. You just felt really free to ask whatever.
>
> We talked about different kinds of things, I guess things that you wouldn't normally ask a professor or something like that. You felt real comfortable asking whatever.

The women also reported that they were able to assist other students in answering their questions. They enjoyed working on problem sets collaboratively and then explaining solutions to each other. They reported the peer collaboration to be valuable and helped them to better understand the concepts being studied.

> I honestly didn't go because I was really struggling with the material. But it was more of a, you know, it was a good way to study. I think that is part of the SI environment where we can all, like, help each other out.
>
> It was comfortable, like there were other people in there that needed help and they actually did help me with a lot of things that I didn't understand. I didn't feel uncomfortable asking anything.

Summary of the SI environment. Overall the women described the SI climate as a safe and social environment in which to engage with biology and to work collaboratively to solve problems. In general, they found SI sessions to be enjoyable. The descriptions the women provided of the SI environment were in stark contrast to the environment that many women described when talking about their previous experiences in science classes (either in high school or college). The women also reported that the ability to ask and answer questions was particularly helpful to them. Additionally, most of them reported enjoying their relationships with their peers and their SI leader who was often reported as a provider of advice and coaching both in and out of the SI sessions. In general, many of the affordance of SI reported by the women in population two mirrored the responses provided by population one.

The Influence of SI on Science Identities

In this section, I will discuss ways in which the SI environment influenced access to science identities for the women which played a role, at least in part, in their transition from non-science majors to students who continued on in biology. In my conceptual framework, I discussed Carlone and Johnson's (2007) model for science identity. I used a modified version of this model as the basis for my interview design as I wanted to probe specific areas to determine how SI might influence the women's access to science identities. The major areas investigated were: (a) interest in science, (b) competence in science, and (c) recognition of self and by others as a science person.

Interest in science. One question that needed to be addressed was whether the women had a continuous interest in science, whether they had an early interest in science that was extinguished, or whether they had never had an inclination towards science until the college level. To answer this question, I asked the women many details about their science histories. I learned about the classes they took, the experiences they had in those classes, their teachers, science experiences outside of school, science role models, and anything else they could tell me about how they felt about science in the past. I then asked them to explain how they felt about science as they entered college and took non-majors biology. Finally, I asked them to explain how they felt about science as they left non-majors biology, after they had experienced SI.

In addition, I wanted to learn not only about how the women report their perceived interest in science, but I wanted to see if they took actions that demonstrated their interest. In this case I asked them to report on additional science courses they had taken after experiencing non-majors biology and SI, their career goals, and how science integrated into their daily lives. The results concerning interest in science are shown in Table 14.

Each of the participants reported an early interest in science, most of which seemed to be encouraged from experiences in their early education. These experiences were memorable to the women (most could remember details of some specific science experience from elementary school), and seemed to pique their curiosity in science. They enjoyed science that was either displayed to them as a demonstration or that was something they could participate in such as a lab or a science project. Some of them reported that they simply liked to experiment.

> I remember a lot of different, of course them they were corny little experiments, but I just thought they were like the coolest things in the world. Like, you know, it was just so amazing to me to watch it, sit there and do little itty bitty things. It was just amazing.
>
> In elementary school I really liked it with the experiments.
>
> I've always had an interest in science since I was young. And that wasn't necessarily in the classes. It was just because I liked trying things.

Table 14

Interest in Science

Code	Explanation	Frequency
Reported		
Early	Felt excited about science; enjoyed science (elementary school)	10
Middle	Felt excited about science (at least some courses); enjoyed science (middle school)	6
Late	Felt excited about science (at least some courses); enjoyed science (high school)	4
Pre-SI	Eager to take college science courses (prior to taking college biology)	3
Post-SI	Eager to take additional college science courses (after taking college biology)	10
Demonstrated		
Additional biology courses	Student voluntarily takes additional science courses (usually to fulfill science education requirements)	3
Minor	Student plans to pursue minor in biology	3
Major	Student plans to pursue major in biology	4
Career aspirations	Student plans to use biology in their eventual career	10
Integration of science in "normal" life	Student frequently engages in science outside of class requirements; reads about science; talks with non-scientists (friends, family, etc.) about science	10

When asked to describe the aspects of science that were either appealing or not appealing to them, there was a great degree of consistency with the women. They all very much liked science that seemed applicable and engaging to them.

> It was more like she gave us an example so it was just kind of like you would relate to it instantly. Like, 'OK, that's how this works' because it is related to things in real life.

However, the women strongly disliked science that they could not connect to something of value to them or that seemed abstract. In particular, they reported not being able to connect with science that was reported to them simply as facts for them to memorize or that did not involve any hands on activities. Most of them reported that as they got older, their science classes involved more long lectures and less "doing" of science in lab-type experiments which was another turn off to them.

> I don't think we studied the more interesting aspects of biology (in high school). It was general. Like 'here it is' but it was not more. I don't know, there was nothing to grab and we just kind of drew notes on the dry erase board and we just wrote them down and that was it.
>
> You just basically do what you are told to do and memorize the book and write everything. Like you learn it back, you don't learn the concepts. You don't ever learn why something happens.

When asked about other high school or college level science classes they may have experienced, the women typically reported not liking them for various reasons. Chemistry and physics in particular seemed to be a deterrent to many of the women as were the impersonal, large college classes that seemed to involve nothing more than rote memorization. The participants reported that they felt the information from those experiences was not relevant or useful to them or that they were directly discouraged by the experience.

> Chemistry was basically titrations, titrations, titrations! Biology, for some reason I can't remember a thing we did in high school.
>
> And then in 10^{th} grade I had chemistry, honors chemistry. And I did not like chemistry at all. I mean I made an A barely, but I didn't like it.
>
> It (chemistry) was my first C (in college)! I was so heartbroken because I never received a C. I don't think I ever got over it. I never got over it. I think I cried for like a week.

> I always did good in classes (science) but didn't enjoy chemistry. Really, really didn't like chemistry.
>
> It (science) just didn't click with me as much. My junior year (high school) I was out of sciences to take. I mean I didn't have one to fit into my schedule. . . And my senior year I took AP environmental and honors physics which I honestly did not like.

Most of these negative feelings started to develop at the high school level and continued through college. The women reported losing their interest in science, and to some degree their confidence in science, during their high school years. They also reported that the aspects of science that were intriguing to them were not the same in high school or that the content was confusing. Unlike their earlier experiences with science where the activities were magical demonstrations, hands-on fun, or something that really clicked with their real-life, this just didn't happen much in high school or college for them.

> I wasn't really interested in it (science). . . . Middle school I kind of lost interest and when I got to high school it was kind of like, 'oh it's this boring class that I had in middle school again'. So I was learning a little but more and I enjoyed it a little bit more but is still wasn't as fun to me (as earlier experiences).
>
> I got good grades and stuff so I thought I knew it. . . And I guess that's the reason why, like, I thought it was the way you are supposed to learn but when I got to college everything was like 'why you do this' and 'why this is the way it is.' And that's when I figured out that I really didn't know.
>
> The teacher was awesome. He explained things very well but I think when I was in the class I understood everything but when I went home and read the book I just didn't understand the content.

Teachers, in particular played a large role in the women's interest in science (or lack thereof) during middle and high school science classes. While "good" teachers provided a positive influence on the women's perception of science, teachers the women perceived as "bad" or ambivalent seemed to play a major role in extinguishing interest in science.

> She (the science teacher) hated our guts! It was terrible. It was just rough because of the way she treated us.
>
> She (the teacher) was kind of rude and . . . .she didn't know what she was talking about half the time. And that's what really irritated me because we couldn't ask her questions that we felt like we got an answer out of. . . I look back on the high school teachers and sometimes wonder if the teachers were actually knowledgeable in what they were teaching how much better it would be.
>
> I think it was like my sophomore year so I was, like, 15 or 16 years old and I think her (the teacher's) lack of being able to explain things clearly really hindered my motivation towards learning it (science) well . . . I didn't have any motivation to study because she couldn't help us. She couldn't explain things.
>
> In high school, I took a biology class that really set me on 'I don't want to take any more biology.' I don't know if it was the course or the teacher but it was really hard. . . She (the teacher) was a little bit strict, very strict, and there was a ton of homework and she probably gave us like 100 questions per night. Just random, well not random, but like a list of questions and you had to answer everything . . . It was graded and everything so I didn't do well in that course.
>
> She (the teacher) told me 'you can't ask any more questions.' She, like, actually told me that in class!

Additionally, several women reported wanting more guidance and direction from their teachers. They felt like they needed someone to recognize their abilities and help them with decisions about their academic pursuits.

> Some kids had the 'I want to do this' but I didn't feel like I really had anything and I think it would have sort of helped me is someone has said, you know, 'do this' or 'this might be an area to think about.'

> I kind of had a complaint in that way (about lack of guidance). I felt like even my parents, nobody really, gave any of us much direction (in science) I think.

As time went on, the women reported more and more negative experiences with their science classes. In terms of selecting a college major, several of the women stated that they did not consider pursuing science in college because they thought that science would be too hard for them. Additionally, some of the women's decisions to be non-science majors were immediately reinforced when they started college. A few women of the women reported that they knew other students who were in science majors and that they were struggling with their coursework. This discouraged the women from considering science majors and taking science classes.

> I was just scared that if I turned into a biology major that I would get into classes, my roommate is a biology major, and she is in classes that are just, she doesn't learn in the class. So she teaches herself everything outside of the class.

While the women described a variety of reasons for abandoning their earlier interests in science, it was not always a case of being directly discouraged or turned off by science education. Some of their decisions were based on their perceptions of what pursuing a college major in science would mean for them. Even though an early interest in science seemed to be present for all of the women, it was frequently coupled with an acknowledgement that science was not to be something that they would seriously consider when they progressed in their educations. They had already resolved in their minds that science was not to be a major for them.

> Science I always liked. Like, if anyone asked me what my favorite subject was of course I would say science all the time but it just wasn't anything I thought I would major in.
>
> I was just kind of like 'it's too hard' and I'm not really ever going to get into that. But it was always an interest to me. I just thought it was fascinating to know how everything is and I just thought it was really cool when I was younger.
>
> I definitely remember when I was really, really young that I actually enjoyed it (science) more than when I actually got into high school or middle school. I always took a lot of science classes but mainly because I seemed to be better at science than I was like any other subject. But . . . when I came to college I definitely never thought I would be a biology major.

One reason cited by the participants as a reason for why the women swayed from science was that they perceived in order to use science in their career that it would be necessary to pursue more education than they wanted to commit themselves to when they entered college. This has been reported in the literature as a commonly cited reason that women stray from science (Etzkowitz, Kemelgor, Neuschatz, & Uzzi, 1994; Seymour, 1992a). They reported that an education in science would take "forever" and it could interfere with their family life. One woman reported that her family's response when she mentioned pursuing science (including professional school) as a career was "you will be done when you are like 30 and by that time you should be married and have a family." Additionally, many women were lured by other majors that promised more financial payoff with less education. Science seemed to be a larger commitment of time to them than most were not ready to make as evidenced by comments such as: "I just couldn't see myself doing this for the next three and a half years" and "A big deterrence was just all of the school. I just feel like it would be so much school and I am already just burned out on school! I'm ready to get into a career."

A renewed interest in science. While all the women showed an interest in science at some point in their lives, most had been turned off to science when they entered college or had simply made the decision that science was not for them based on their perceptions of science as a college major or career. Some reported that they enrolled in non-majors biology in order to fill a general education requirement imposed by the university. They also reported that they weren't expecting to get much out of the class. This explanation was offered to explain how one women wound up in non-majors biology:

> It was required. I had to take some sort of science class. And even though I really didn't like AP biology I wanted to give it another try. I figured I would try it again and it was part of my general education (requirements). So, you know, kill two birds with one stone!

Once the women began to experience non-majors biology and actively engage in SI, their perspectives began to change. The excitement they felt about science when they were younger re-emerged. They explained that biology (and science) seemed interesting again and that they were learning things that seems applicable to their lives and having the opportunity to talk about those things in SI. They reported deep engagement with the material (particularly in SI) and a desire to truly understand biological concepts.

> I loved how the class gave examples again - like my chemistry teacher in high school (who she thought was wonderful). It related it to more real life things where it was more fascinating like 'oh, so that's why that's like that', you know? Like, I just got more in to it. Like cancer was one that I really enjoyed just because it was more, it was more topics that everyone wants to know about and like they hear about all the time but they just don't know exactly what it is.

> Biology, within the first three weeks, just, the subject matter was just, I don't know, it was captivating. I really, really enjoyed it. It surprised me because I didn't even enjoy biology at all (in past experiences). . . . I actually enjoyed studying for this. . . .This really has real life applications and there is a whole world out there that biology is the door opening to it.
>
> I think when you are sitting there learning in the class (lecture), passively learning, you are like 'uggg.' I mean this stuff is interesting and I like it and everything, but when you actually get into it (in SI) and study it yourself you are like 'oh, so that's what happens' and you connect Thursday's notes to Tuesday's notes . . . When it clicks you start to enjoy it.
>
> I loved it. My friends and my family got annoyed with me cause I'd go home and talk about random things I had learned in class and SI.

Obviously, this renewed interest in biology for population two elicited a change in the academic plans these women had for themselves. After they changed their major, minor, or concentration of their education major to biology, they generally reported a high level of satisfaction with their choice.

> And since I changed my major to biology I just started enjoying, just like every single step of the way, every step like cell biology and even the labs. It's just an interesting journey, you know, like it's not unbearable 'Gosh, I can't wait until this semester is over' . . . When I found biology I felt like that was my niche, you know, and it helped me not only academically but I guess confidence-wise too.
>
> I realized that (previous major) was not what I wanted to do and it was totally somebody else's idea. And then when I got here (to biology), I thought well, you know. I don't know how I changed my mind (to consider medical school). But I somehow got into the whole biology thing and I liked it a lot.

Competence in biology. All of the women displayed a high level of competence in biology and, with the exception of one woman, all reported feeling highly competent in science at some point in their academic career. Several of the women stated that they felt better in science than other disciplines. Comments from the women such as; "I felt like I was really good in science," "Science was really my strong point" and "I was always stronger in science than anything else" surfaced when I asked the women to tell me how they would compare their science abilities to their abilities in other disciplines. However, even for the women who reported science as their strong area, they still performed well in other disciplines. Other women reported that while they were successful with science, they felt equally successful with other disciplines. They did not necessarily perceive their abilities in science to exceed their abilities in other courses.

I felt that the participants typically possessed a "good student" identity as defined by Carlone (2003, 2004). This implies that, for some women, being a good student in science may be the result of simply being a good student in all subjects. Each of the women in this study reported receiving good grades in all disciplines in their earlier educational experiences. While they enjoyed science (at least at some point in their academic career), they had other interests such as math or English that they also felt highly competent with. When asked about their academic performances in the past, they all reported that while they typically performed well in science, that they also performed well in other disciplines. They considered performing well in all of their classes to be a priority for them. Most of them seemed fairly confident in their abilities through the high school level however this confidence diminished for some of the women as they entered high school and college. The data for the competence theme are reported in Table 15.

Table 15

Competence in Science

Code	Explanation	Frequency
Perceived		
Self	Student reports increased competence in biology as a result of SI experience	10
"Good student" identity	Student is generally competent in all subjects, including science	10
Transferability	Student reports using skills from SI in other disciplines / courses	6
Demonstrated		
Biology exams	Performance on a single exam	10
Biology course	Performance in the course (semester grade)	10
Science talk	Demonstrates appropriate use of science discourse during SI and in conversations about biology	9
Other science courses	Performance in additional college science courses	9

The majority of the women in the study clearly were above average in their accomplishments throughout their academic careers. In Table 17 (found later in this chapter), I have indicated the overall grade point averages for each of the women in this study at the time of their interview and at the time of their graduation. For those who have yet to graduate, their current grade point average is reported. In addition to the women generally having above average grade point averages, several had participated in particularly distinguished and competitive science activities in their earlier science education experiences that went above and beyond those of a typical student. A few examples are listed below:

> The summer before my junior year, I went to North Carolina Summer Ventures in Science and Mathematics in the area of Medical Science. Only ten students in the state got into that particular division and all ten were girls! I worked in the

> Anatomy and Cell Biology lab at Brody School of Medicine at ECU with a team of doctors, techs, and graduate students to do a research project on colon cancer cells. Then, the summer before my senior year, I attended Governor's School East in the Area of Natural Science. Here, I was in Physics, Microbiology, Biology, and Chemistry. As you can guess, Biology and Microbiology were my favorites. We were also given seminars on current issues and advances in the science field.
>
> I remember being halfway fascinated by it (science), but not really captured by it by and means. But when I got to the eighth grade it really started. I really got interested in it because my teacher in the eighth grade was really into this Women in Science program that is run through Appalachian State University. . . And so she got to select two students out of the eighth grade, two female students, and I was one of them . . . Every couple of months we'd go take a weekend up to Appalachian and we got to work with the top professors in the science department. We'd spend all day Saturday, literally, from early in the morning to probably dinner time doing experiments, it was pure hands on . . .We got to work in the brand new laboratories. We got to work outside. During the summer we got to spend two weeks up in Boone. For two weeks straight every single day we would go out and do something new. I guess I loved working with that stuff.

Overall, the women in population two displayed a high level of competence in science and in other disciplines. Some of them had experienced very unique science opportunities that had increased their competence in science and given them exposure to a realistic model of science. Generally, their confidence wavered at some point which typically corresponded with the time at which their interest in science was lost. As their interest in science renewed, so did their perceived competence in science.

Recognition. The final influence on access to science identities investigated in this population was recognition. I was interested in hearing how the women recognized (or did not recognize) themselves as a science person and how they felt recognized by meaningful others as a science person. The data for the recognition theme can be seen in Table 16.

Table 16

Recognition of Self and by Others

Recognition	**Explanation**	**Frequency**
Of self		
Early	Perceived self as good at science (in early experiences)	5
Middle	Perceived self as good at science (in middle school)	8
Late	Perceived self as good at science (in high school)	7
Pre-SI	Confident in ability to succeed in college science courses	5
Post-SI	Confident in ability to succeed in future college science courses	9
By others		
Teachers	At least one teacher praised student; invited student to participate in special programs; encouraged student to pursue science	6
Lack of by teachers	Student reported at least one teacher that was perceived as uninterested in teaching or in student success	7
Parents/Family	Valued science ability; promoted science activities as part of "normal" life; encouraged student to pursue science	2
Mentors	Advisors or other mentors recognized science ability; invited to participate in special programs; encouraged student to pursue science	3
SI leader	Perceived praise from SI leader; encouraged student to take more biology courses	5
Peers	Other students acknowledged competence; asked for help in studying by other students	6

Some of the women reported an early recognition of their science selves. As was the theme with interest in science and perceived competence in science, self recognition declined throughout middle and high school. By the time women entered non-majors biology and SI, they were not necessarily recognizing themselves as science people as evidenced by their original choices of major.

In terms of recognition by others, several of the women reported that in earlier science classes, such as in middle and high school, they were recognized by teachers as being good in science. However, for every teacher that the women felt recognized by, there was at least one other teacher reported that they felt did not recognize them. In general, women seemed to remember more of the details relating to a science experience relating to lack of recognition by teachers than experiences involving positive recognition by teachers. The impact of this sort of negative recognition has been reported by others (Carlone & Johnson, 2007) which, for some women, can have very long lasting impacts on their sense of competence in science.

Several of the women described helping their peers in middle and high school who had difficulties in science and that those peers would come to them regularly for help in science. Not only did the women help their peers study science (and were, as such, recognized as science people by their peers), but in some cases they perceived themselves as teaching science to their peers as a result of a poor instruction. In one case, the student reports that the teacher actually told the other students to go to her for explanations.

> They (the students) would ask us questions and . . .so we definitely had people coming to us asking us questions (about science) and we were definitely there for explanation and could explain what was going on.
>
> Like when we found out we would have a quiz, they (other students) would come over to my table and, you know, ask 'What do we have to know? What's going on here?'
>
> Some of my friends got together and were like 'We need to understand chemistry. Heather, do you want to help us?' and I was like 'Sure, why not?'

> We had study groups and stuff like that and we just all, it was mostly my friends in there, we got together and I would kind of take over and teach what they didn't learn in class or explain things or something extra.
>
> My chemistry teacher couldn't answer a question one day so he was like 'I almost told the other students to go ask Amy' to explain something. I don't know what the concept was but he (the teacher) knew that I understood it and that he couldn't make it come across to normal people that weren't incredibly brilliant like himself.

As the women entered non-majors biology and engaged in SI, most of the participants said that they felt like their abilities in biology were recognized by another meaningful other—their SI leader. The SI leaders were described by the women as having served as a source of encouragement and support throughout the semester. The women seemed genuinely appreciative of their leaders taking an interest in them and encouraging them. In fact, two of the women in this study eventually became SI leaders for non-majors biology based on the endorsement they received from their SI leaders.

Throughout their experience in non-majors biology and SI, the women in population two came to recognize themselves as science people although I suspect two of the women did not embrace that label as strongly as the other eight women. I speculate that the supportive climate of SI coupled with the women's renewed interest in biology and recognition of themselves as science people provided them access to their science identities that had been overlooked for some time. I will close this section using the words of one woman to describe how her recognition of self has developed as a result of her foundation in non-majors biology and SI:

> Just the more biology I take, the more interesting it gets. It builds up on itself . . .and you are like 'oh wow – I remember this from last semester', and it just, I

> don't know, for me personally, maybe I am weird, but it helps build my confidence. Like I am good in biology. Like 'wow, that makes me feel good'. Kind of builds up my self esteem a little bit rather than when I came in here as a freshman undeclared and had no clue what I wanted to do and really no clue what my strengths and talents were.

Where are the Women of Population Two Now?

Some time has passed since most of the interviews but I have kept in touch with each of the women with the exception of one whom I cannot locate. Six of the women have graduated and are beginning their careers or pursuing additional graduate or professional degrees while four of the women are still in their undergraduate programs. In Table 17, I have summarized academic information on each of the women. In order to demonstrate their competence, I have reported their grade point averages at the time of their interview and again either at the time of their graduation or, if they have not graduated, their current grade point average. This table also indicates the degree pathway pursued by the women as well as specific notes on the career aspirations for the women. Specific demographic information about the women can be found in Appendix D.

In each case, the women have sustained their interest in biology and have continued on a plan similar to what they anticipated when I interviewed them. Six of the women have graduated. While one of the women graduated with a BS degree in psychology and a minor in biology, I have been unable to contact her to inquire about her career after graduation. The other five women who graduated either continued their education or pursued a teaching career. One of the women graduated with a BS in biology and highest honors. She became an SI leader and later was a TA for non-majors labs which are typically taught only by graduate students. She plans to be a physician and just completed her first year of medical school. Another of the women is currently in a Master's program for neurobiology/clinical psychology and may consider a doctoral program that involves neuro-biology in the near future.

Table 17

Summary Information on the Women in Population Two

	Year of interview	GPA	Academic Pathway	Career notes
1	2006	3.462 (at time of interview) 3.255 (current)	Pursuing degree in business honors program and minor in biology	Plans to apply to medical school
2	2006	4.0 (at time of interview and final)	Graduated with a degree in education with a science concentration	Will be a teaching science in the fall
3	2006	3.878 (at time of interview) 3.910 (final)	Graduated with a BS in biology	Completed first year of medical school
4	2006	2.980 (at time of interview) 2.155 (current)*	Pursuing a BS in biology	Plans to apply to optometry school
5	2006	3.463 (at time of interview) 3.024 (final)	Graduated with a BS in biology	Completed her first year teaching high school biology
6	2006	3.615 (at time of interview) 3.731 (final)	Graduated with a degree in education with a science concentration	Will be teaching science in the fall
7	2006	3.835 (at time of interview) 3.846 (final)	Graduated with a BS in psychology with a minor in biology	Enrolled in masters program in psychology.
8	2006	3.514 (at time of interview) 3.423 (final)	Graduated with a BS in psychology and a minor in biology	No information available
9	2007	3.125 (at time of interview) 2.798 (current)	Pursuing a degree in criminal justice with a minor in biology	Plans to pursue a career in forensic science
10	2007	3.806 (at time of interview) 3.855 (current)	Pursuing BS in biology with minor in biotechnology	Plans to pursue a research career in biotechnology

Science teaching is the direction three of the women took. One of the women completed a BS in biology and utilized the lateral entry program so that she could teach high school biology. She also served as an SI leader during her senior year. She has completed her first year of teaching and reports her career to be very fulfilling. Two other women completed their student teaching and graduated in May 2008 with majors in education with science concentrations. Both have science teaching jobs arranged for the fall of 2008.

For the women who have not yet completed their degrees, one is pursuing a BS degree in business with university honors and business honors. In addition, she is completing her minor in biology next semester and plans to apply to medical school this year. Another is pursuing a BS degree in biology and stumbled academically for a year (as noted by the * in Table 17) but has since recovered and is continuing on with her biology degree and has hopes of applying to optometry school in the future. One woman has struggled a bit with her career path and has changed her major to criminal justice. However, she still retains a strong interest in biology and is pursuing forensic science. The woman I interviewed most recently has successfully completed additional biology classes and plans to complete a BS in biology, ultimately focusing on a career in biotechnology research.

Overall, each of these women, in some way, has retained an interest in biology not only academically, but in their careers as well. This population of non-majors students has produced some unexpected outcomes including a future physician, three science teachers, and a potential research scientist. All of these women reported that they were greatly influenced by their experiences in non-majors biology and SI which helped them to re-visit their science selves and have empowered them to make new choices concerning their academic and career goals.

Summary of Research Question Two

From each of the women interviewed in population two, there were several themes that were apparent with the majority of the participants. Those themes included an early interest in science that somehow got derailed, a "good student" identity including high achievement in multiple disciplines including science, and a confidence and recognition of themselves. SI afforded these women a chance to enhance their competence and confidence in science, engage with biology, recognize themselves as science people, and ultimately rediscover their science identities. All of the women in this population committed to an academic pathway that included a significant number of additional science classes. In following the women's academic and career paths, it is apparent that their interest in science has longevity.

Summary of the Chapter

The meanings of SI for two populations of women have been reported in this chapter. The safe, supportive, and collaborative environment of SI helped both groups of women feel comfortable engaging with biology, ultimately increasing their competence in biology. This environment also increased interest in biology for both groups of women. However, for the women in population two, their experiences in non-majors biology and SI caused a significant change in their academic and career plans.

In comparing the two populations of women, there was one area where there seems to be a distinct difference between the groups. Population one reported low levels of recognition of self and by others and relatively low levels of competence in previous science experiences. In particular, these low levels of recognition and scientific competence may explain their status as non-majors students. While SI was reported by this group of women to play a significant role in their success in biology and their recognition of their own abilities in science, they still seemed hesitant to embrace their abilities and recognize themselves as science people.

The women of population two had a much different experience with recognition for science ability. Most of them connected with science at an early age and, at some point, saw themselves as science people. While they reported teachers and experiences that eventually turned them off to science, they also reported teachers that recognized them for their science abilities. While they came to college as non-science majors for various reasons, they had demonstrated high levels of scientific competence in the past. For them, taking non-majors biology and participating regularly in SI reminded them of what they liked about science, renewing their interest in science and providing them access to their science identities. For these women, their experience was transformative on many levels.

In the next chapter, I will discuss the significance of these findings for both populations of women. Implications of these findings for research and practice will be presented along with future directions for this research.

CHAPTER V

CONCLUSIONS

The primary intention of this study was to investigate the meanings women make of regular participation in an SI program associated with non-majors biology. Whereas the effect of regular SI participation on achievement as measured by grades is well documented in the literature across multiple disciplines (Blanc et al., 1983; Collins, 1982; Congos et al., 1997; Congos & Schoeps, 1993; Hodges & White, 2001; Ogden et al., 2003; Shaya et al., 1993; Zaritsky & Toce, 2006), the meanings participants draw from SI participation have not specifically been addressed. Because women have typically been marginalized in science education (Guzzetti & Williams, 1996; Kahle, 1996; Oakes, 1990; Tindall & Hamil, 2004; Woolfolk, 2001), and because women so eagerly take advantage of SI associated with non-majors biology at my institution (Warner, 2005), they became an excellent source of insight as to the meanings of regular SI participation.

This project addressed two specific research questions. The first question was designed to gather information on the meanings of SI for women who attend regularly. Hearing directly from the women who attended SI provided me with explication concerning why women attend SI, the affordances provided by regular SI participation, how women depict the learning environment of SI, and how women describe science as they experienced it in SI. The second research question was designed to provide an understanding of the role SI participation plays in terms of access to science identities for women who change their majors, minors, or educational concentration to biology as a result of their experiences in non-majors biology and SI. Understanding the meanings of SI for the women in this unique situation allows me to contribute something contrary to the typical reports in the literature that women typically emigrate from science as their academic careers progress (Seymour & Hewitt, 1997). The data provided by the women in this study demonstrate that an unlikely group of women (non-science majors) can, under certain supportive circumstances, be encouraged to immigrate in to science.

This chapter will begin with a discussion of the meanings of SI for women who participate regularly, followed by an explanation for how these meanings and descriptions of the SI environment relate to the literature on best practices in science education. This will be followed by a discussion of how SI participation may facilitate access to science identities which encourages women to further pursue science education and careers. Implications of these findings to research, to practice, and to society will be addressed. The chapter will conclude with an acknowledgement of the limitations of this study and a description of potential future directions for this research.

Research Question One

My first research question asked the following: What meaning does SI hold for women who participate regularly in the program? In order to answer this question, five sub-questions were asked:

a. Why do women attend SI on a regular basis?
b. How do women describe the *benefits* (affordances) of SI?
c. How do women describe the *drawbacks* (constraints) of SI?

d. How do women describe the *learning experiences* in SI?

e. How do women describe *science* as they experience it in SI?

In the introduction to this study, I noted two major problems with post-secondary science education. The first problem was that the traditional pedagogy that pervades undergraduate science courses leads to a low level of student satisfaction and retention, and the second problem was that women are abandoning science at a greater rate then men. As the meanings of SI are discussed in this section, substantiation will be provided to support the notion that regular attendance in SI can be a solution, at least in part, to both of these problems.

Insights from Population One

It has been suggested that in order to decrease the gender gap in science education it is critical to promote self confidence, offer praise, give constructive feedback, allow for small group interactions, and create a sense of community (Tindall & Hamil, 2004). Even with the best of intentions, it may be impossible for an individual instructor to achieve all of these goals in a large enrollment lecture class. However, the data collected for this study suggest that SI can provide an environment that is conducive to achieving the recommendations from the literature. The descriptions of SI provided by the women in this study provided verification that SI defies the typical pedagogy in large science classes and provides an environment in alignment with what the literature suggests as best practices for science education. The specific alignments of SI with the science education reform literature will be discussed in the next section.

In terms of the meanings of SI participation constructed by the women of this study, my elucidation is that SI provided them with a safe, social, and supportive climate in which to engage with biology and to increase their competence in biology. This experience ultimately helped them recognize themselves by augmenting both their perceptions of their own competence in biology and their attitudes and interest towards biology and science in general. This was noteworthy because the women in population one typically reported negative histories in science along with a low level of recognition by self and by others in science.

This study was able to demonstrate that regular SI participation increased course grades by a full letter grade as compared to those that did not use SI regularly. However, based on the data provided by the women, participation in SI had a much larger meaning than simply providing a means to increasing grades in the course. The women's participation in SI had a dramatic effect on enhancing their feelings about their own abilities to be successful in science and their enjoyment of biology. Moreover, the experiences in SI were reported by the women to have some longer-term consequences including a self-reported increase in scientific literacy, long-term interest in science which led to taking additional science courses in some case, and an integration of science into daily life as demonstrated by reading about science and discussing science with meaningful others in their lives.

Why do women participate in SI? It has been reported that a typical girl receives 1800 less hours of academic attention by teachers by the time she enters college as compared to boys, making women less likely to speak up and ask questions in college science classes (Woolfolk, 1998). However, in SI, nearly all of women reported feeling comfortable and participating regularly in SI sessions. The question is why did they participate so freely in this environment?

One unique feature of this particular SI program is that men do not utilize the program in the same way that women do. During the 2007-2008 academic year, 106 students attended SI for non-majors biology on a regular basis. Of that group, 86 were women while 20 were men. This meant that in many SI sessions, there were few and sometimes no men attending, such that women always greatly outnumbered the men. One might argue that when the sex ratio is this skewed in SI sessions the women feel more comfortable to actively engage and participate. They are not competing with males for attention from the SI leader or other students and they can feel comfortable in contributing to a discussion (Hall, 1982). While my study did not specifically address this variable, I suspect that these women would have actively participated in SI had there been more men in the sessions. I would argue that the climate of the SI environment (which is in major contrast to the typical large lecture course) is what sets the comfort level for these women (Seymour & Hewitt, 1997), more so than the gender ratio in the session. The literature specific to the post-secondary setting suggests that women flourish in environments that de-emphasize competition (Alexakos & Antoine, 2003; Rosser, 1997; Seymour & Hewitt, 1997) and provide peer support (Hanson, 1996; Kahveci, 2006) which clearly aligns with the structure of SI. Additionally, class size at the post-secondary level has been implicated as a critical factor in terms of the perceived degree of chilly climate in a classroom (Constantinople et al., 1988) for women. As evidenced by the descriptions provided in the women of this study, the small size of SI sessions coupled with the climate of SI were the variables that set the comfort level for women.

Summary for Research Question One

Overall, the women in population one reported meanings of SI that had much more to depth than simply a means to increasing course grades, although SI clearly did influence their course grades. The safety, comfort, and support of the SI environment provided a place where women could feel comfortable practicing biology and increase their competence in biology. It helped them feel connected to their large lecture course. The collaborative and social climate provided a setting that made the women feel as though they could be successful in biology despite the fact that many of them had reported never being successful in science in the past. Ultimately, these women not only felt successful with biology, they were successful with it. They left the class with self-reported increases in scientific literacy, a stronger interest in science, and a more positive attitude about science, all of which are stated goals in the science education reform literature.

Because of my long-term involvement with SI at my institution and preliminary interviews performed, I entered this study with certain expectations of what meanings SI would hold for women. I expected the women to recognize SI as a means to increase their confidence and competence with biology while providing an environment that was safe and non-threatening for them to practice biology. What was surprising for me was to gain insight into the women's perceptions of themselves as science people (or not). Hearing from the women in this study provided valuable insights as to why they may have become non-science majors based on their past experiences with science education that diminished their interest in science as well as their lack of recognition (by others and of themselves) as science people. It also elucidated major differences in terms of previous interests and recognition in science between the women in population one and two of this study.

An additional area that provided pleasantly unexpected results in this study was the women's long-term interest in science and future plans related to science in population one. While this group had no plans to pursue science as a career, their experiences in SI led to a more intense interest in biology, increased science literacy, a positive attitude towards science, and an interest in taking additional science classes. While admittedly small, this group even produced women who indicated an interest in becoming science teachers in the future. Given my own experiences with non-majors students over many years, I was not expecting to see these sorts of changes.

The meanings of SI illuminated in this study are in need of further examination with a larger group of women but have provided some unique perspectives on SI that have previously have not been investigated. These results lead towards a better understanding of the women who take non-majors biology as well as a better understanding as to how they perceive SI as supporting them.

SI as One Means of Reforming Post-Secondary Science Education

There are many suggestions provided by the literature which elucidate the sorts of changes that need to occur in science education to support students' varied learning preferences and to increase their satisfaction in their science courses. However, there is also a noted resistance of science instructors, particularly at the post-secondary level, to change and try new strategies in their classes (Klionsky, 2004) with the consequence that student satisfaction in these classes is typically low (French & Russell, 2006). In addition, class size is reported as a major deterrent to student satisfaction and persistence in science (Meyer, 2002; Salter & Persaud, 2003; Seymour & Hewitt, 1997) yet the trend in enrollment in these introductory science classes continued to climb despite the calls in the literature for reduced class size. The implementation of SI programs for large lecture classes can have profound effects for students with a minimal amount of effort on the part of the instructor.

The literature reports that as a consequence of early educational experiences, women report low perceived ability in science (Brickhouse et al., 2000; Oakes, 1990; Seymour & Hewitt, 1997), negative attitudes toward science classes (Alexakos & Antoine, 2003; Hanson, 1996; Oakes, 1990), and a lack of motivation to pursue additional studies in science (DeBacker & Nelson, 2000). In talking with the women in this study about their previous science experiences, they confirmed all of the above. They did not recognize their own abilities in science, they had negative experiences in science classes, and they obviously were not motivated to pursue advanced studies in science as evidenced by their non-majors status. In this section I will examine the SI environment as it was described to me by the women of this study and discuss how it aligns with pedagogy lauded as best practices in science education.

The calls for reform in science education have pointed to several major problems with how we teach science. It has been repeatedly suggested that the typical structure and design of these courses is not conducive to how students in general (Klionsky, 1998; Lawrenz et al., 2005; Lord, 1997, 2001), and women in particular (Eisenhart & Finkel, 1998; Rosser, 1997; Seymour, 1995b; Seymour & Hewitt, 1997), learn best. These poor experiences in science education affect all students, but women in particular are highly affected. Women have often been failed by their science educations, which leads them to develop the opinion that science is uninteresting, not worthy of further pursuit, nor something that is relevant or appropriate for their futures or careers (Carlone, 2004). Clearly, the SI environment has provided something unique to the women of this study to, at least in part, combat these earlier opinions that they held of science.

Alignments of SI with Best Practices in Science Education

The SI environment provides the setting for many best practices in science education (Mintzes & Leonard, 2006), two of which were mentioned frequently by the women of population one, and will be discussed in this section. First, the SI environment serves as an excellent environment for students to engage in vexing problems and practice thinking critically. The women of this study repeatedly mentioned their appreciation of difficult practice problems in SI which helped them learn to apply material and to think critically about scientifically situated issues. Second, the nature of the SI session structure is already established in a way that lends itself well to constructivist learning strategies. In addition, the opportunities for both constructivist learning and critical thinking in SI afforded the women the ability to engage with scientific discourse, or science talk, which also increased their confidence and competence in biology.

Critical thinking. It is reported that secondary educational experiences lead to college students who are less than prepared for thinking critically (Berkheimer et al., 1990; Cheung et al., 2002; Moffat, 1994; Roseman & Koppal, 2006). If students are in fact under-prepared for critical thinking activities in college, they may be disadvantaged by not often having the opportunity to engage in critical thinking activities in their large, introductory science classes. It is reported that instructors of large science lecture courses often omit critical thinking activities in their classes citing class size and lack of time and resources as rationales to explain why they are unable to integrate more critical thinking into their courses (Klionsky, 2004; Shell, 2001). SI provides an ideal setting to promote critical thinking. The safe, non-threatening, and low stakes environment sets a comfort level that encourages students to participate in problems solving. Because SI sessions always consist of small groups, there is much interaction with peers and the SI leader which can allow for frequent feedback that can guide students as they work through vexing problems. I suspect that having these opportunities in SI motivates the women to practice biology and problem solving even outside of SI sessions because they perceive the benefits (in terms of grades) that can be afforded to them as the result of their efforts.

Constructivist learning. The SI environment also affords the opportunity for techniques that facilitate constructivist learning to be utilized. These sorts of techniques are reported to help students of all academic levels (Scheurman, 1998; Skrtic et al., 1996) and can be particularly attractive to women by facilitate the inclusion of women and improving their performance in science classes (Barton & Osborne, 1999). In addition to improving performance, constructivist learning environments can foster the sort of climate that provides a social, supportive and safe place for women to gain competence in biology. It has been suggested that the women are bonded by their common situation of facing an unfamiliar experience of what to expect in the course which sets a climate of safety, respect, reassurance, and challenge (Clark, 1998). Unlike traditional pedagogy, constructivist techniques allow students who might never feel comfortable participating in a traditional class format to feel comfortable contributing to a small group (Marlowe & Page, 1999). The women in this study repeatedly asserted their comfort in the SI environment and their willingness to participate actively.

Increasing opportunities to engage in science talk. In providing women with problem solving activities in SI, they were often required to propose solutions to problems that typically involved specific and technical scientific discourse or science talk. Given their non-majors status, the opportunity to engage in science talk with other individuals on a regular basis may not be afforded unless the student specifically seeks out an environment such as SI. For students with little experience in science, it has been reported that they can benefit from additional guidance in constructivist learning activities, specifically with learning about the process of science and learning science talk (Bianchini, 1997). The women in this study reported that the SI environment allowed them to converse with each other frequently using science talk which helped strengthen their understandings of biological concepts. I consider this to be an encouraging trend as the use of science discourse is one way of displaying a potential science identity to others (Brown, 2004). While the women in population one did not show an inclination to pursue science further, they did display potential aspects of science identities by their voluntary use of science talk in SI. Constructivist learning strategies that encourage science talk have been promoted as a means of enhancing science identities in a variety of educational settings (Brown, 2004; Hughes, 2001; Reveles et al., 2004).

Alignment of SI in the Context of Women's Ways of Knowing

Based on current learning theories, the social organization of SI makes it a likely candidate for increasing students' knowledge and understanding in science. In addition, SI's structure also aligns well with what we know about the learning environments where women learn best. The women in this study repeatedly described their experiences with SI to be in alignment with what we know about women's learning preferences.

Providing a more personal experience. Class size has been shown to be one of the most important factors in student satisfaction and persistence within a science (Meyer, 2002; Salter & Persaud, 2003) and a critical factor in terms of the degree of chilly climate perceived by students in a classroom (Constantinople et al., 1988). For women in particular, the typical large lecture class used in introductory science courses can be a deterrent keeping them interested in science (Seymour & Hewitt, 1997). With the inability to control course size, SI affords a valuable option in allowing for students to have collaborative learning opportunities in a small group setting outside of the classroom. The small size of SI was repeatedly cited by the women as a factor that encouraged active participation in SI session.

Providing a social and collaborative environment. Collaborative learning experiences have increased achievement and satisfaction in a variety of settings for all students (Lawrenz et al., 2005; Norton et al., 1997; Salter & Persaud, 2003). While this study focused specifically on women, the literature provides support for the idea that the collaborative learning environments are equally as beneficial to male students (Seymour, 1995a).

In studies focused specifically on women, we know that they prefer learning environments that: include small group social interactions and collaborative learning (Alexakos & Antoine, 2003; Brickhouse et al., 2000; Seymour & Hewitt, 1997), provide peer support (Hanson, 1996; Kahveci, 2006), de-emphasize competition amongst students (Alexakos & Antoine, 2003; Rosser, 1997; Seymour & Hewitt, 1997), and provide encouragement from their instructors and their peers (Oakes, 1990). In addition, cooperative learning environments have been reported to increase self-esteem for women (Alexakos & Antoine, 2003; Debacker & Nelson, 2000) and promote an environment of self confidence by providing frequent feedback and praise to students (Tindall & Hamil, 1994).

The descriptions of SI provided by the women in this study are in complete alignment with the existing literature on women's learning preferences. Additionally, the SI environment appears to enhance classroom belonging for women by increasing interpersonal support and encouragement (Freeman, Anderman, & Jensen, 2007; Goodenow, 1993; Hamm & Faircloth, 2005) which fosters an increased sense of academic motivation (Goodenow, 1993; Freeman, et al., 2007). The structure of the SI sessions provides women with an environment in which they can feel comfortable in engaging with biology. Women indicated that they enjoyed the social and collaborative nature of SI. They reported a high level of safety in the SI environment that encouraged them to actively participate with no fear of being wrong. They found their peers and SI leader to be supportive and indicated that the SI environment increased their confidence in and comfort with biology. Most importantly, they reported a significant increase in their feelings concerning their ability to be successful with biology which was largely attributed to their participation in SI.

SI as Tool to Support Science Identities

Regular participation in SI played an unexpected role for some women enrolled in non-majors biology by supporting those who had lost interest in science and promoting access to their science identities. This resulted in significant modifications to their educational and career plans. While it has been suggested that the science talent pool is typically set prior to grade 12 (Berryman, 1983), and it is documented that women who do retain an interest in science as they enter college emigrate from science at an alarming rate (Seymour & Hewitt, 1997), the literature is silent on the issue of women turning towards, instead of away from, science at the college level.

Although I am not advocating for the goal of non-majors biology courses to be recruitment of women into science, it could serve a small role in an untapped pipeline for women into science. Given that 47% of students are undeclared majors at typical large state universities (Tobias, 1992b), these students, along with others, will likely be taking a science course to fulfill their institutional general education requirements. This study has demonstrated that non-majors biology courses, coupled with regular SI participation, can fulfill the needs of the large population of non-majors students and, at the same time, provide support for the smaller population of women who may immigrate into science.

Research Question Two

My second research questions investigated the role of SI in relating to science identities. The question was as follows: What does SI afford in terms of the science identities of successful women who decided to pursue science further after participating regularly in the SI program? In order to fully answer this question, the following sub-questions were asked:

a. What are the ways the women connect their experiences in SI with their *interest in science*?
b. What are the ways women connect their experiences in SI with their *scientific competence*?
c. What are the ways women connect their experiences in SI with the ways they *define themselves as science learners/doers*?
d. What are the ways women connect their experiences in SI with the ways they *feel recognized by others as competent science learners/doers*?

It has been reported that 95% of students complete a year of biology in high school, yet few students aspire to major in science (Blank & Gruebel, 1993), and 50% of that small group end up leaving their science major eventually (Seymour & Hewitt, 1997). The National Research Council reported that the teaching of high school biology is completely unsatisfactory (Committee on High School Biology, 1990) with serious deficiencies in all levels of science education. To amplify this problem, participation and interest in science diminishes steadily more so for women than men during high school (Hanson, 1996; Oakes, 1990). This may explain, in part, the large audience of non-science majors found at colleges and universities and provide context for understanding the anxieties of non-science majors, particularly in women. The question that lingers is, based on this negative history with science education and what one might expect based on the reports in the literature, why did the women in population two change their academic and career plans to include biology?

In some way, the women's experience with non-majors biology and SI served as a means for them to access to their science identities which they had not connected with in some time. The literature suggests that identities are not fixed and can change over time (Brickhouse et al., 1999) and that most students are likely to have multiple identities, some stronger than others (Gee, 2000). At some point in their early academic careers all of the women in population two seemed to be on an academic path that included a strong interest in science. However, that path was either interrupted or put on hold only to be rediscovered after a positive experience with a non-majors biology class and SI. While the women may have developed other identities along the way at different points in their academic careers, they have also regained access to their science identities. It has been suggested that the development of science identity is socially situated (Brickhouse & Potter, 2001) and perhaps the social and collaborative structure of SI played a significant role in providing access to science identities for the women in population two.

Variables influencing science identity. I looked to Carlone and Johnson's (2007) model of science identity to inform my conceptual framework and to help pinpoint the factors that influenced these women's science identities. Their model describes the development of science identity in terms of competence, performance, and recognition of self and by meaningful others. In constructing my interview protocol, I utilized a modified version of the Carlone and Johnson model to look into three specific themes that seemed to relevant to the SI environment. Specifically, I investigated the role of SI in supporting: (a) interest in science, (b) competence in science, and (c) recognition by meaningful others and of self.

The women in population two all reported an early interest in science that was extinguished prior to college. While most of them stated that they had entered non-majors biology with low expectations for the course, they left with a renewed interest in biology. The women reported that the SI environment provided a special way of looking at biology that interested them and elicited a positive response to science similar to what they had reported in their earlier science education experiences. Several women described specific examples during SI sessions where the group would have time to fully investigate specific concepts that did not strike the women as particularly interesting previously. However, when they had the chance to fully engage with the concept in SI they became fascinated with particular topics and concepts. They reported that having the time to discuss the concept with others, and, at times, to have the SI leader to interject a fascinating tidbit or trivia piece about the concepts were pivotal in increasing their interest in biology.

The climate of SI was reported by the women to be safe, supportive, and collaborative in similar ways to how the environment was described by the women in population one. Each of the women in population two reported that their competence in biology (both perceived and demonstrated) was improved by attending SI. Most of these women had not felt competent in science for some time as they had been discouraged by previous science classes, which is typical based on the evidence in the literature (Oakes, 1990; Seymour & Hewitt, 1997; Tindall & Hamil, 2004). The women reported that the SI environment was one factor that helped them understand biology and feel confident applying their knowledge to unique situations. All of the women reported that their academic achievement in the class had improved as a result of their SI attendance.

Recognition was a key factor for the women in population two. In contrast to the women in population one, all of the women in population two had received some sort of recognition for their science abilities at some point in their early academic career. However, as they progressed in their science education, most reported a lack of recognition or negative recognition in science which related to their decline in interest in science which is in alignment with the literature (Carlone & Johnson, 2007). However, SI provided a new opportunity for the women to be recognized for their science abilities. The women reported that they felt like their abilities in biology were recognized by others such as the SI leader and other students in SI.

The role of the SI leader seemed particularly meaningful to the women. They reported that they SI leaders served as a coach and cheerleader to support and encourage them through the class. The women seemed genuinely appreciative of their leaders taking an interest in them and encouraging them. In addition, other participants in SI sessions who were less comfortable with the material were coming to these women for help or asking them for answers and explanations. This sort of recognition from their SI leaders and peers helped bolster the women's confidence in their own science abilities.

A critical issue for this population of women was recognition of self. Unlike most of the women in population one, nearly all of the women in population two had reported some level of recognition of their science abilities and interests at an earlier point in their science educations. However, that recognition faded through middle and high school. As the women entered non-majors biology, they generally reported that they did not feel comfortable with their own abilities in science. During the course of the semester, that recognition of self changed. As the women engaged with biology and renewed their interest, they reported that the confidence and competence increased. With this came recognition of self as "science person," someone motivated and able to pursue a science-related career.

Summary for Research Question Two

While my sample size is small, I have observed a new trend of women entering the science pipeline after positive experiences with non-majors biology and SI. There is no definitive answer to explicate why these women took a delayed path to embracing science in their college careers. However, it is clear that the SI environment supports a variety of factors that are important to science identity. The climate of SI allows for a growing interest in biology along with increased confidence and competence in biology. This leads to women being recognized by others, and, most importantly, provides an environment where the women can come to recognize themselves as science people. For these women, their non-majors biology class coupled with their SI experience provided a unique opportunity for those with a previously derailed interest in science to revisit those interests.

To conclude this analysis of my second research question, I would like to draw on a quote that seems most appropriate to offer at least a partial explanation as to why the women of population two gained access to their science identities and had a major shift in their academic plans as a result of their non-majors biology and SI experience. Eisenhart and Finkel (1998) wrote:

> If the activities of school science represent identities that are interesting, believable, and possible for students to achieve (given existing demands and expectations), then there is greater likelihood that students will participate in science activities and pursue scientist identities. (p. 240)

I find this statement to be most appropriate for the women of population two. Their experiences in SI and non-majors biology provided them with a place to see science as interesting and believable and a place where they could increase their achievements and competence in science.

Affordances of a Modified SI Structure

While not specifically addressed by my research questions, there was an additional theme that emerged during the course of this study. Part of the women's extremely positive perceptions of SI were influenced by the modified structure of SI developed for my course. The traditional model for SI is well in alignment with best practices in science education and has many documented successes. However, there are a few areas where additional support is advantageous for non-majors students who are not always well prepared for studying science at the college level.

In Chapter II, I described my personal enhancements to the traditional SI model. During my interviews with the women in populations one and two, as well as in the comments section of the survey, the women repeatedly mentioned specific aspects of SI that were particularly helpful to them, regardless of the fact that there was no specific prompt directing them to comment on this. Given that the SI program associated with my non-majors class has an extremely high attendance rate as well as a high level of student satisfaction and achievement, it seems appropriate to mention specific aspects of SI's structure that affords such success and to provide explicit recommendations for instructors based on my own experiences with SI.

Every woman I interviewed made deliberate comments about the weekly problem sets and activities provided for the SI sessions. They reported that these problem sets served as a means to practice complex problems and as a launcher for discussion on confusing or difficult concepts. They also reported these activities as being a major influence in increasing their competence in the course. Because I was actively involved in designing weekly problem sets and activities for SI, I was also heavily promoting the program with my students. I find that connecting SI with the class makes it meaningful to the students and motivates them to engage with the SI program. Because I frequently tell my students how important I think SI is, this provides them with an impetus to at least visit an SI session to see what it is about. Active instructor involvement in this case requires minimal effort. I would simply remind students of SI during my daily class announcements and I would send email reminders on a regular basis, particularly when we were covering very difficult concepts in class, to remind the students to take advantage of SI. In addition, I provided frequent feedback concerning performance to the students. After each class assessment, I would present students with the averages comparing students who attended SI with those that did not. Without exception, the group that attended SI always had higher averages than those that did not and often the difference was so pronounced that it did catch the students attention. This provided students with even more evidence as to why they should be attending SI. The data collected in this study reinforced my theory that the frequent communication about SI by their instructor helped to demonstrate a connectedness between the instructor, the class, and SI, which helped students to see value in SI participation.

In addition to providing SI students with meaningful activities and a deliberate connection with their course, I also am compelled to stress the importance of instructors' active involvement in recruitment and selection of the most appropriate SI leader for their population of students. While many competent students meet the basic qualifications to be selected as SI leaders, competence within the discipline alone is not enough to make an effective SI leader. Nearly every woman I interviewed for this study made comments about how important their SI leader was in helping them both during and outside of sessions. They all felt comfortable with their leaders which I see as a major factor in setting the climate of SI sessions.

My SI leaders are most frequently students who came from my non-majors class and are education majors. I find this combination to be appealing to a wide group of students. Having an SI leader that has been through the non-majors class puts the leader in a position where the current students can relate to them. They identify with this leader knowing that they too have been through the non-majors course which gives the leader a sort of credibility with the students. When I have used SI leaders who have not taken non-majors biology and are declared biology majors, students sometimes told me that they didn't think the leader could relate to them as a non-science major or that the leader knew so much biology (since they were a biology major) that she would talk on a level above the non-majors students which was confusing for the students. For some reason, they looked at this type of leader more as a "teacher" who had lots of knowledge that was intimidating to them.

I also find that education majors are a great match for the SI leader position. Not only are they dedicated to gaining experience working with students, but they seem to truly care about the success of the students. While it seems so simple, my non-majors students truly respond to instructors and SI leaders that they perceive as caring about their success. Many women in this study made comments about their SI leader caring about them. While it is a generalization, education majors who have experienced non-majors biology typically have a very caring quality that most students are drawn to. Overall, it is critically important to select a leader with great competence (i.e., an understanding of the major biological concepts in the course), but also with a personality and background with which students can easily relate to and feel comfortable with.

Four of the women I interviewed from population two had participated in SI for other science courses (either before or after their SI experience in non-majors biology) and stopped attending because they did not feel that the sessions were well designed, that their instructor was connected to the program, or that they felt engaged or excited by their participation. This clearly demonstrates that all SI sessions are not the same. With minimal effort on the part of the instructor to pick the best leader for the group and to keep the sessions purposeful and connected to the lecture course, that there can be an enormous payoff in terms of the utility of the program to students.

Implications

Throughout this chapter I have outlined the specific findings of this study as they relate to the existing literatures. In the following sections I will summarize the implications of my research findings as they contribute to the literature, to practice, and to society.

Contributions to Research

This study provides several contributions to the research for the specific literatures relating to SI effectiveness, post-secondary science education reform, gender bias in science education, and science identity. It also illuminates a new way of connecting these bodies of research that has not previously been explored.

In terms of contributions to the research on SI, this study has provided additional support to an already strong base of literature promoting the usefulness of SI for all students in terms of increasing grades. As has been the case with other studies on SI, students who attended SI on a regular basis in their non-majors biology class made one letter grade higher in the course than those students that did not use the program regularly. In addition, a gender bias in this population of SI participants has been identified that is strongly skewed towards women as the primary participants in SI. This study provided new perspectives on SI in terms of the meanings SI holds for women who participate regularly that are not solely linked to increasing grades in a course.

While there are many ways to approach the problem of science education at the post-secondary level as described in the science education reform literature, I offer SI as one solution for increasing students' achievement and satisfaction in large, introductory science courses. The descriptions provided by the women in this study make it clear that SI was a major factor in their success and satisfaction with their course. While the literature offers many science education reform suggestions that are certainly worthy of consideration by instructors, a well designed SI program is one of the easiest tools for college instructors to implement in order to increase the achievement and satisfaction of students in their courses.

Essentialist perspectives on feminist science education have pointed towards a deficit with women that accounts for the gender bias in science education. Others contend that there is no deficit in the women but the pedagogy used in science education turns the women away (Seymour & Hewitt, 1997). Two factors that have been shown to keep women engaged in science are the pedagogy used by the instructors as well as a positive perceived classroom climate (Seymour & Hewitt, 1997). This study provides support for the notion that there is not a deficit with the women in non-majors biology. They simply needed an appropriate environment that provided the opportunity to engage with biology on a deeper level while being safe and supportive. This study, like others (Seymour, 1992a; Seymour, 1995a; Seymour & Hewitt, 1997), suggests that the deficit is with how we approach science education. The data from this study made it clear that, for this population of women, their achievement, attitudes, and perceptions about science can be drastically increased in a matter of a semester when given the appropriate supportive tools.

This research offers a unique contribution to the growing body of science identity research by providing evidence contrary to the literature by suggesting that women can gain access to science identities at a later age than previously reported. It also provides novel evidence that women can immigrate into science, as opposed to emigrating from science, at the college level, serving as a small but untapped pipeline into science. This research also provided additional evidence to affirm the idea that recognition is a critical piece of science identity access.

Contributions to Practice

The results from this study have several implications for practice which will be detailed in this section. Most notably, I will discuss the benefits of establishing or making adjustments to an existing SI program for college instructors who teach large, introductory science courses.

This study re-affirms what the literature has already suggested about the effectiveness of SI in increasing achievement in students. For instructors who have not implemented an SI program, there is good reason to do so. SI supports all students, but this study shows in particular how it can support women. In non-majors classes specifically, many students come to the class having been biased by negative science experiences in the past. Implementation of SI programs is one way to support students and provide a means to increase achievement and satisfaction with classes that typically have a low level of both.

For those instructors who already have established an SI program, I have offered modifications to the SI model which have made SI more attractive to a larger audience of students. Each of these modifications is easy to implement with only a modest amount of time and effort required on the part of the instructor. These modifications, according to the women in this study, have a major impact on students' perceptions of the utility and value of SI.

Overall, this study shows that SI can support students through their non-majors science course while increasing their competence, attitudes, and interest in science. Previous studies show SI to support all types of students, and this study demonstrates the unique attributes of SI as seen by the women who regularly participate in the program. In fact, SI simultaneously supports the needs of two very different populations of women – the "typical" non-science majors who will not continue in science and the women who regain access to their science identities during their experiences in non-majors classes and SI.

Finding any way to attract women to science, even if it is a relatively small pipeline, is a positive step in decreasing the gender gap in science and yet another reason for instructors to consider augmenting their courses with SI support. This research also provides a tool for screening women in non-majors science classes with early histories of interest and recognition in science for their potential to emigrate to science.

To conclude this section, I will generalize the results of this study to a different population—students enrolled in introductory majors science courses. Although this study was conducted with a non-majors population, I believe there is enough evidence to suggest that modified SI programs, such as the one described in this study, could be particularly valuable to freshman majors science classes were retention is a major problem. Unfortunately, 50% of women who enter college as declared science majors wind up leaving (Seymour & Hewitt, 1997). Perhaps if a supportive SI program was in place for them, one that enhances their interest and engagement with science while increasing their competence and recognition of themselves as science people, it might be possible to retain more of these women in science.

Contributions to Society

It has been reported that many college freshman and sophomores have not yet met the stated goals for high school science literacy (Roseman & Koppal, 2006) and that only 22% of college graduates have achieved science literacy (Miller, 1998). In the American Association for the Advancement of Science's (AAAS) *Science for All Americans* (1990), "science literacy" was promoted as a top priority for science education. This study demonstrated that, in the non-majors population, women reported an increased scientific literacy which was largely attributed to regular SI attendance. Not only do the women report increased scientific literacy, but they also report increased interest in science and demonstrate behaviors that show some degree of integration of science into their daily lives. Producing graduates with a higher level of scientific literacy leads to a public with a better knowledge of science that can make sound and informed judgments on scientific issues. This study suggests that SI can be one means to achieving this important goal.

This study, while on a small scale, has revealed a potential pipeline of women to two critical areas in science. The women who change their majors to biology as a result of their experiences in non-majors biology and SI can serve as a potential, albeit small, pipeline for women into science-related careers. Given the shortage of women in science, the attraction of any women to the profession, even in small numbers, is significant. This study has also shown that women who participate regularly in SI may develop some inclinations to pursue teaching science as a profession. Given the major shortage of qualified science teachers (National Academy of Sciences, 2006), this population of women may provide a useful contribution to the profession of science teaching.

Limitations

The limitations of this study are well recognized. The research site was selected because of the well-established SI program coupled with a unique situation where women were immigrating into science after being declared as non-science majors. This unique situation led to data being collected from one population, for one course, at one institution. However, it could be argued that the purposeful selection (Patton, 1990) employed in this study provided a unique advantage by selecting participants who were uniquely qualified to provide specific information to help answer the research questions (Maxwell, 2005).

Because only a single SI program was investigated in this study, there was a limited sample size due to the fact that only a limited number of women were regular participants in the SI program. While data saturation was achieved in this study, repeating the study with a larger population of women and studying a different group of women at a different institution would strengthen the validity and generalizability of these findings. In particular, the statistical analysis provided for the survey data was limited by the relatively small number of participants coupled with a large number of survey items. However, this survey was designed primarily to be descriptive in nature. Because no survey instrument specific to the meanings of SI had been developed previously, the purpose of my survey instrument was simply to determine how widely held themes from the interviews in population one were amongst a larger population of women. This information will allow for future modifications of the survey so that it can be administered to a larger population of women.

Researcher bias is another potential limitation of this study. I have an admitted closeness to this program which, in my opinion, enhanced this study. Without my insider status and inquisitive nature concerning how SI supports women, the women of population two would have remained undetected and invisible. My research design was constructed making every effort to decrease researcher bias. This included my long-term involvement in the study, the use of multiple means of data collection to triangulate data, detailed transcription and coding, frequent member checks, and routine follow ups with the women who were interviewed in the study.

I do recognize that the nature of this study provided for an entanglement of two variables: the influence of SI on the women of this study as compared to the influence of their non-majors course. The women in this study reported positive experiences with SI and with their non-majors course. It is likely that a combination of these variables led to their achievement, success, and interest in science. However, the deliberate comments made by the women in this study concerning SI provide substantial support for the role it played in their achievements in and perceptions of science.

A final limitation of this study is that women were self-reporting on several prompts in both the surveys and interviews. In the case of course grades or enrollment in additional science courses, this self-reporting was easy to validate by consulting transcripts and official enrollment records. However, the women's self-reporting on their scientific literacy was more difficult for me to validate. While I know many of these women personally and feel that they do demonstrate a good degree of scientific literacy, I did not have a means to specifically measure that ability in this study. However, even with self-reported data that were not validated by an additional instrument in this study, the women reported themselves to feel more scientifically literate after experiencing non-majors biology and SI, which may make them more empowered and engaged in future science-related decision making and life situations.

Future Directions

Future plans for this study include continued administration of a modified version of the survey each semester to all women who are regular SI participants in order to gather a larger sample size and achieve greater validity. One planned modification is to develop a true pre and post survey instrument to be administered to all women in non-majors biology. This will require surveying every woman in non-majors biology at the beginning of the semester before they experience the course and SI and then surveying again at the end of the semester. This will allow for interesting comparisons between the group that attended SI during the course of the semester and those that did not attend SI.

It is suspected that there will be significant differences concerning attitude, interest, and competence between the two groups.

The survey data in this study provided some interesting trends that could use further probing. For example, the women in population one reported in their surveys that SI increased their abilities to be successful in other science classes. Following this trend to determine how successful the women were in later science courses would be a logical progression for following the progress of the women in population one.

A second area that needs further investigation is the role recognition plays for the women in both populations of this study. A major distinguishing factor between populations one and two in this study was related to recognition in science. The women in population one had a history of negative or no recognition in science while the women in population two had a history of at least some positive recognition in science. Modifications to the survey instrument and interview protocols are planned to further probe on the types of recognition received in non-majors biology and SI as compared to types of recognition received in other science settings.

For the women in population two, continued follow up is planned to determine where their eventual careers will take them and whether those careers will include science. I also plan to increase the number of women studied in this population by continuing to identify women who change their majors, minors, and educational concentrations to biology. Hearing from a larger audience of women in this population is critical for a true understanding of the role SI plays in access to science identities and to immigration into science.

Conclusion

The non-majors science population is large, diverse, and worthy of being understood on a deeper level. It contains different types of students, with different science histories, different academic needs, and different goals. Given the gender bias that exists in science education and the call for science education reform at all levels, this study has revealed SI to have the ability to support varied populations of non-majors women simultaneously. For the typical non-majors student that will not continue in science, SI helps them to increase their competence, interest, and attitudes towards science with the additional benefit of enhancing scientific literacy. For a small sub-population of non-majors students, SI seems to be a means of attracting women to science after being declared as non-science majors. The unique and supportive environment created by SI is one factor that promotes access to science identities and enhances long-term interest in science.

While much of the science education reform literature has focused on the problems with science education, this study provided an example of a best case scenario for women. The data collected in this study contribute to a growing body of literature on the impact of SI on achievement for all students, while contributing new evidence towards an understanding of how SI leads to higher levels of achievement, success, and satisfaction with science courses for women. In addition, this study contributes something new to the literature on science identity by examining a previously invisible population of women who immigrate into science at the college level.

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Appendix A

Interview Protocol for Population One

Science Biography:

1. Describe any previous science classes you may have taken (at any grade level).
   - What were your feelings about those classes? Describe some specific experiences and memories.
2. Describe your "science self" prior to taking Biology 1110.
   - Did you feel your understanding of science was good?
   - What sorts of grades did you make?
   - Did you feel motivated in science classes?
3. Why did you initially decide to major in something other than science when you came to college? How did this lead to your decision to take Biology 1110?

Experiences in Biology 1110 and SI

4. You regularly attended SI while enrolled in non-majors biology. Describe your experiences in SI to me as if I knew nothing about the program.
   - Why did you attend?
   - How often did you attend?
   - How did you participate in SI?
   - Describe the typical climate of an SI session.
   - What were your interactions like with other participants?
   - How did SI help you in this class and with science in general?
5. What encouraged you to continue attending SI throughout the semester?
6. How would you describe the primary benefits of SI participation?
7. Were there any drawbacks or constraints to attending SI? If so, how would you describe those?

Post-SI thoughts:

8. How does science seem different to you now as compared to before you took this class and participated in SI?
9. Did your experience in SI make you more comfortable or confident with science? Explain.
   - As compared to your "pre-Biology 1110 self" do you feel more comfortable with science now? Please explain.
   - How was your performance in biology class?

Appendix B

Survey Instrument for Population One

SI Survey

1. Consent Information

During this survey you will be asked to answer questions concerning your experiences with the Supplemental Instruction (SI) program that you attended while you were enrolled in Biology 1110 at UNC Charlotte. The survey will take less than 10 minutes to complete. You are free to refuse to participate or to withdraw your consent to participate in this survey at any time without penalty or prejudice; your participation is entirely voluntary. Your privacy will be protected because you will not be identified by name as a participant in this project.

All data from this study will be confidential. Any written information on this study will use pseudonyms for the study site and participants. All data will be kept in a secured location and will be destroyed by shredding three years after the study is completed. There are no risks associated with participation in this study.

The research and this consent form have been approved by the University of North Carolina at Greensboro Institutional Review Board, which insures that research involving people follows federal regulations. Questions regarding your rights as a participant in this project can be answered by calling Mr. Eric Allen at (336) 256-1482. Questions regarding the research itself will be answered by Jennifer Warner by calling (704) 687-8535.

By clicking on the "next" button on this survey, you are agreeing that you are 18 years old and are willing to participate in the project.

2. Interest in Biology BEFORE Biology 1110 and SI

*** 1. Please answer these questions while thinking about yourself BEFORE you took Biology 1110 and used SI.**

	strongly agree	agree	neutral	disagree	strongly disagree
In general, I found biology interesting.	○	○	○	○	○
I talked to friends and family about biology.	○	○	○	○	○
I would sometimes read news articles that related to biology.	○	○	○	○	○
I was interested in taking more biology classes.	○	○	○	○	○
I felt I would be able to use what I learn in biology after the course was over.	○	○	○	○	○

3. Interest in Biology AFTER Biology 1110 and SI

SI Survey

* **1. Please answer these questions while thinking about yourself AFTER you took Biology 1110.**

	strongly agree	agree	neutral	disagree	strongly disagree
In general, I find biology interesting.	◯	◯	◯	◯	◯
I talk to friends and family about biology.	◯	◯	◯	◯	◯
I sometimes read news articles that relate to biology.	◯	◯	◯	◯	◯
I would be interested in taking more biology classes.	◯	◯	◯	◯	◯
I will be able to use what I learn in biology after the semester is over.	◯	◯	◯	◯	◯

4. Competence in Biology

* **1. Please answer these questions based on how you feel about biology now.**

	strongly agree	agree	neutral	disagree	strongly disagree
Biology seems fairly easy to me.	◯	◯	◯	◯	◯
I like biology best when it really makes me think.	◯	◯	◯	◯	◯
I like biology problems that I will learn from, even if I make a lot of mistakes.	◯	◯	◯	◯	◯
I find it fairly easy to explain biology concepts to other people.	◯	◯	◯	◯	◯
I will/did make a good grade in Biology 1110.	◯	◯	◯	◯	◯
I worked hard in biology because I wanted to get better at it.	◯	◯	◯	◯	◯
In biology class and SI, I was expected to understand ideas in science, not just memorize them.	◯	◯	◯	◯	◯
I would not have done as well in biology had I not attended SI.	◯	◯	◯	◯	◯

5. Recognition of Self and by Others

SI Survey

* 1. Please answer the following questions

	strongly agree	agree	neutral	disagree	strongly disagree
I think of myself as being good in most types of science.	○	○	○	○	○
I made good grades in science during middle school/high school.	○	○	○	○	○
Other students think I am good at science.	○	○	○	○	○
My teachers in previous science classes thought I was good in science.	○	○	○	○	○
I feel confident about my own ability to learn new biology concepts.	○	○	○	○	○
I'm comfortable in my ability to solve difficult biology problems.	○	○	○	○	○
In SI, I am recognized for trying hard in biology.	○	○	○	○	○
Other students ask for my help to study biology.	○	○	○	○	○

6. The SI Environment

* 1. Please answer these questions about the SI environment.

	strongly agree	agree	neutral	disagree	strongly disagree
In SI, it is(was) okay to make mistakes as long as I was learning.	○	○	○	○	○
I enjoyed learning biology during SI.	○	○	○	○	○
In SI, we had time to explore and understand biology ideas.	○	○	○	○	○
I participated in discussions during SI.	○	○	○	○	○
I was able to interact with other students in the class during SI.	○	○	○	○	○
SI sessions provided an efficient way of studying biology.	○	○	○	○	○
SI sessions helped me feel better about my ability to be successful in biology.	○	○	○	○	○
SI sessions were fun.	○	○	○	○	○
I felt successful with biology during SI sessions.	○	○	○	○	○
I felt comfortable during SI sessions.	○	○	○	○	○
I participated more in SI than I did in lecture class.	○	○	○	○	○
I helped other students during SI sessions.	○	○	○	○	○
I didn't worry about getting questions wrong	○	○	○	○	○

SI Survey

in SI sessions.					
Other students helped me during SI sessions.					
The SI leader helped me during SI sessions.					
I feel like I studied better in SI than I do by myself.					
I felt supported during SI sessions.					
SI helped teach me how to study biology on my own.					
I felt respected during SI sessions.					

7. After the Semester is Over . . .

*** 1. After taking Biology 1110 and using SI it is possible for me to:**

	strongly agree	agree	neutral	disagree	strongly disagree
Think scientifically					
Make informed decisions about scientific issues					
Help other students study biology					
Be successful in other college science classes					
Take more science classes					
Use my biology knowledge to solve new problems					
Eventually become a science teacher					
Feel comfortable reading about biology in the news					
Use biology in my career					
Encourage other students to take biology					
Become an SI leader					

8. Additional Comments

1. Please feel free to write any additional comments you might have about your SI experience here:

9. Exit Page

Thank you for your participation. Your responses will help improve the SI experience for future biology students.

Appendix C

Interview Protocol for Population Two

Science Biography:

1. Describe any previous science classes you may have taken (at any grade level).
    - What were your feelings about those classes? Describe some specific experiences and memories.

3. Describe your "science self" prior to taking Biology 1110.
    - Did you feel your understanding of science was good?
    - What sorts of grades did you make?
    - Did you feel motivated in science classes?
    - Did other students and teachers recognize your abilities in science?
    - Were you confident in your abilities in science classes?

4. Why did you initially decide to major in something other than science when you came to college?
5. Why did you take Biology 1110?

Experiences in Biology 1110 and SI

6. You regularly attended SI while enrolled in non-majors biology. Describe your experiences in SI to me as if I knew nothing about the program.
    - Why did you attend?
    - How often did you attend?
    - How did you participate in SI?
    - Describe the typical climate of an SI session.
    - What were your interactions like with other participants?
    - How did SI help you in this class and with science in general?

7. What encouraged you to continue attending SI throughout the semester?

Post-SI thoughts:

8. Did your experience in SI make you more comfortable or confident with science? Explain.
    - As compared to your "pre-Biology 1110 self" do you feel more like a "science person" now?
    - Did you/do you feel competent in biology? Does this extend to other science disciplines such as chemistry and physics?
    - How was your performance in biology class?
    - Did other students recognize your science abilities?

9. What made you change your mind in terms of selecting biology as a major or minor (or selecting science concentrations within the education department)?

Appendix D

Demographic Information for Population Two

This table provides demographic information on the women in population two. Their age at the time of the interview, ethnicity, and high school information is provided for each women. Additional notes of interest are provided were applicable.

Subject	Age	Ethnicity	High School	Additional notes
1	20	Caucasian	Private	Participating in two honors programs in college
2	44	Caucasian	Public	Began college at a traditional age and then returned in her early 40s; has attended several colleges and universities
3	21	Indian	Private	Born in India and educated in Zimbabwe; moved to the United States at 17 and began community college before transferring to a university
4	20	Caucasian	Public	
5	21	Caucasian	Private	Attended a conservative Christian high school
6	20	Caucasian	Public	Participated in the North Carolina Teaching Fellows program
7	22	Hispanic American	Public	Attended year round school with a heavy focus on science
8	21	Caucasian	Public	Participated in supplemental science programs for high achievement students during middle school
9	20	Caucasian	Public	
10	21	Caucasian	Public	