WHY DO I NEED TO KNOW MATH?

THE IMPACT OF SUPPLEMENTAL INSTRUCTION FROM THE STUDENT’S

PERSPECTIVE

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Abstract

Many students enter college unprepared for the study of mathematics and other subjects that require a strong math background. As a result, students have difficulty applying math concepts in non-math courses and frequently ask the question “Why do I need to know math?” Institutions of higher education must find ways to support these students in order to improve retention and graduation rates. In this study, an instructional intervention called Supplemental Instruction (SI) is used to help students to link the application of math concepts to their chosen discipline of study. SI is a tutoring approach that targets at-risk courses versus at-risk students; removing the remedial stigma experienced by many at-risk students. SI programs consist of voluntary tutoring sessions that occur weekly throughout an academic term and are facilitated by an SI Leader. This SI Leader is an expert in the topic area covered by the SI program and also attends all classes with the enrolled students. This study employed a qualitative research approach designed to capture an understanding of the lived experiences of engineering technology students who participate in a SI program focused on connecting important math concepts to complex engineering applications. This Interpretive Phenomenological Analysis study incorporated the use of individual interviews to collect rich data capturing the lived experiences of the participants. The qualitative data collected and analyzed sheds light on the experiences of students who have participated in this SI program.

*Keywords:* Supplemental instruction, making learning relevant, student success, mentor, mentoring.
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Chapter One: Introduction

The purpose of this phenomenological study was to investigate the individual experiences of certain college students trying to make sense of their participation in a Supplemental Instruction (SI) program as they navigated a math intensive engineering course. The knowledge generated in this study is expected to inform the SI research community and all faculty and staff involved in SI. This study used Interpretative Phenomenological Analysis to illustrate the phenomenon under study.

The chapter begins with a brief overview of the research related to Supplemental Instruction programs to provide context and background to the study. The rationale and significance of the study is discussed next, drawing connections to potential beneficiaries of the work. The problem statement, purpose statement, and research questions are presented to focus and ground the study. Finally, the theoretical framework that serves as a lens for the study is introduced and explained.

Context and Background

College students face many academic challenges including the application of mathematics to solve real-life problems (DeCorte, 2004; Micari & Light, 2009; Verner, Aroshas, & Berman, 2008; Zinser, 2012). More specifically, many cannot connect math concepts to applications within their academic disciplines. This disconnect can be partially tied to their high school experience (Hoyt & Sorensen, 2001) where instruction becomes segmented and many students become less engaged in the learning process (Malm, Bryngfors, & Mörner, 2012; Wright, Wright, & Lamb, 2002). Their ability to investigate interconnections between what they learn is limited because the teacher has too much material to cover and not enough time (Daggett, 2005). As a result, college students frequently ask why they need to know math, even
though most technical disciplines require a solid foundation in algebra or higher and many students enter college unprepared for the study of mathematics (Corbishley & Truxaw, 2010; McCormick & Lucas, 2011). To complicate matters, pass rates in math intensive courses are low (Boughan, 1996). To assist students, many colleges offer math tutoring services. However, the tutoring services alone, while helping students who take advantage of them, have not shown enough of a positive impact on student math performance. An instructional intervention is required to assist more students in applying math concepts within the courses of their chosen academic discipline (Verner, Aroshas, & Berman, 2008).

The instructional intervention that is investigated in this study is a supplemental instruction (SI) math program. SI focuses on “at-risk” courses or courses with a greater than 30% D, F and withdrawal rate (Arendale, 1997) and provides assistance on an outreach basis in regularly scheduled out-of-class study sessions that begin the 1st week of class (Arendale, 1997; Etter, Burmeister & Elder, 2000; Lockie & Van Lanen, 2008). A good SI program should deliver help to students before they find themselves in academic difficulty (Congos & Schoeps, 1993). Many SI researchers have focused on “at-risk” math courses (Burmeister, et al., 1994; Burmeister, Kenney, & Nice, 1996; Fayowski, & MacMillan, 2008; Harding, Engelbrecht, & Verwey 2012; Phelps & Evans, 2006; Porter, 2010), but only few have focused on math intensive, discipline specific courses (Etter, Burmeister & Elder, 2000; Jones & Fields, 2001; Oja, 2012; Parkinson, 2009). Therefore this study seeks to understand how students make sense of their lived experience in an SI program as they navigated a math intensive engineering technology course.

Rationale and Significance

Supplemental instruction was first introduced by Deanna Martin at the University of
Missouri – Kansas City in 1973. Over the years, many researchers have found positive effects for students who attend SI sessions, including higher final grades and fewer lower grades and withdrawals in the targeted course (Arendale, 1997; Congos & Schoeps, 1993; Fayowski & McMillian, 2008; Ogden, Thompson, Russell & Simons, 2003; Shaya, Petty & Petty, 1993), higher GPAs (Ramirez, 1997), increased persistence (Arendale, 1997; Hurley, Jacobs, & Gilbert, 2006; Ogden et al., 2003), application of study and note taking skills, acquired in SI sessions, in subsequent courses (Jarrett & Harris, 2009) and improved graduation rates (Arendale, 1993; Zerger, Clark-Unite, & Smith, 2006). All of these positive benefits for students also translate into benefits for faculty and administrators in the form of better prepared students, improved retention rates, and higher graduation rates.

This problem is significant at Tech College as it is for many other institutions. As evidenced by Parkinson (2009), historically, in the first year of a biotechnology program, students have found problems in understanding and problem solving in mathematics (calculus) and chemistry. As experienced at Tech College, more and more students taking the Accuplacer math placement exam are placed into remedial math courses. Placement into a remedial math course delays students from being able to start their discipline specific classes. Tech College’s experience shows that when students are not taking courses in their chosen discipline, they get frustrated and have a higher likelihood of withdrawing. In addition, when these students take math intensive, discipline specific courses, they have trouble linking math concepts to applications within their discipline. It is recommended, at a broader level, by Verner, Aroshas, and Berman (2008) that technology applications should be integrated in basic mathematics courses in order to increase students’ motivation, connect mathematics to other disciplines and facilitate the understanding of the mathematical concepts.
For many students, without reliable contexts to anchor meaning, they see math as a meaningless cloud of abstract symbols (Steen, 2007). The SI program documented in this study resulted in students having more confidence in applying math concepts in solving complex engineering problems.

**Research Problem and Research Question(s)**

This study seeks to understand how students make sense of their lived experience in an SI program designed to help them to link math concepts to their application in solving complex engineering technology problems. Based on this specific problem of practice, the following question was used to focus this research.

1. How do Tech College students make sense of and attach meaning to the SI program designed to connect math concepts to their engineering technology course?

**Definition of Key Terminology**

**Accuplacer** - a suite of tests that quickly, accurately, and efficiently assesses reading, writing, math, and computer skills.

**At-risk courses** - courses with a greater than 30% D, F and withdrawal rate

**Interpretive Phenomenological Analysis** - is an approach to *qualitative research* with an idiographic focus, which means that it aims to offer insights into how a given person, in a given context, makes sense of a given *phenomenon*.

**Instructional intervention** – in this study an instructional intervention is an educational program designed to make a positive difference in student outcomes.

**Supplemental Instruction programs** – an instructional intervention that provides assistance on an outreach basis through regularly scheduled out-of-class study sessions that begin the 1st week of class and that are facilitated by a SI Leader.
SI Leader - a peer who has successfully taken the targeted course in the past who attends all classes, performs all assignments and then facilitates the SI sessions.

SI Supervisor – a faculty member that collaborates and supervises the SI Leader and in collaboration with the SI Leader determines the content to be covered in each SI session.

SI session – a weekly out-of-class study session typically 50 minutes in length.

Tutoring services – in this study tutoring services are any math tutoring offered to all students through an Academic Skills Center or formalized tutoring center.

The following section of this chapter will include a description and discussion of social learning theory which served as the theoretical lens for this study.

Theoretical Framework

Social learning theory is an appropriate lens through which to investigate experiences of students participating in a Supplemental Instruction (SI) program. Albert Bandura (1977) explains that learning is a social process and takes place through the observation of the behaviors of others. He views social learning theory as a mixture of environment, behavior, and an individual’s psychological processes. Fundamentally, this theory may help us to understand the learning that happens in a SI session. The desired outcome is that the participants will create new or greatly improve existing behaviors that include motivation, attention, and memory.

Social learning theory is relevant for analyzing social perceptions with regard to how people form impressions and make inferences about other people and how they react to other people when observing them. This is pertinent to this study of the lived experiences of students participating in SI, as people adjust their behaviors based on what they think the people around them are thinking or how they are behaving. Bandura’s (1977) explanation of social learning theory stresses how observing and modeling other people and their behaviors as well as attitudes
and reactions to others are pertinent to the learning process. Further, he explains that not only external, environmental reinforcement like praise from the SI Leader, but intrinsic reinforcement such as pride, satisfaction, and a sense of accomplishment are important in order for students to be motivated to retain the modeled behavior. This emphasis on internal thoughts and cognitions helps to connect learning theories to cognitive developmental theories. This is why Bandura describes his approach as a social cognitive theory. He goes on to state that learning occurs through continuous reciprocal interactions of cognitive, behavioral, and environmental stimuli and he notes that rarely do people learn without seeing the behavior performed by others (Bandura, 1977).

Furthermore, the key attributes of social learning theory are supported by the work of psychologist Lev Vygotsky, who stated that the individual and the society around them are not mutually exclusive in the learning process (Vygotsky, 1978). Vygotsky (1978) contended that cognitive development in education is a process involving social interactions and mediated by tools created from the societal and cultural environment. In turn, these social and cultural environments support development through collaborative efforts. However, Vygotsky also stated that it is vital that the individual educator serve as an active learner for the development process to occur. In the SI learning environment, SI Leaders are active in the learning process and are constantly expanding their personal knowledge. As a result, they are able to bring increased self-confidence and course knowledge to their SI leadership position, thus increasing their image as an "experienced learner", a role to which other students can aspire (Stout & McDaniel, 2006).

Socialization has a tremendous impact on how students learn and what they think is relevant. SI programs have successfully incorporated small group collaborative learning techniques so that when individual students get stuck on a problem, they don’t give up, they are
supported by the other group members who help to solve the problem. Groups of students collaborating also become exposed to alternative problem-solving strategies, and are much less fearful of generating and answering questions among themselves than individually and directly to the instructor in class, and as McKeachie and Svinicki (2006) states, “students learn best what they teach!” (p. 10). Through the use of authentic problems, linking math to the student’s disciplinary courses can be achieved. Making learning relevant, in general, is an important part in helping students succeed and will motivate them to continue their studies and to complete their education. It is important to develop “connections between students’ everyday lives and science so that they have tangible reasons for continuing the lifelong learning of science” (Jenkins, 2011). The same can be said for math. Furthermore, Gambrell (2011) states that “students are more motivated when tasks and activities are relevant to their lives” (p. 173).

Bandura’s (1977) Social Learning Theory explains that students go through four steps or processes when learning. The first step is referred to as Attentional, focusing on what the student observes and more importantly, what the student extracts as important modeled behaviors in the learning process. Therefore, modeled behaviors that are engaging to observing students will be sought out. The second step is referred to as Retention, focusing on what observing students retain from the modeled behavior. More specifically, what modeled behaviors have the observing students converted to images and symbols that can be recalled at a later date. The third step, referred to as Motor Reproduction, is the ability of the observing student to convert the retained images and symbols into actions for future learning. Initially, when attempting to recall these images and symbols students typically need feedback to make adjustments so that their learning becomes more effective (Bandura, 1977). In the SI environment, this feedback is provided by the SI Leader. Finally, the fourth step, referred to as Motivational, is how observing students express
or reproduce the modeled behaviors that are self-satisfying to them. Therefore, exposing students to various learning behaviors provides them options of modeled behaviors that can be retained and reproduced based on what works best for them. Not all observed behaviors are effectively learned. Factors involving both the model and the learner can play a role in whether social learning is successful. The four steps discussed above and how they can be implemented in a SI session is explained in more detail below:

**Attentional.** In order to learn, observers need to be paying attention and anything that detracts their attention away from the modeled behavior will have a negative effect on their learning. If the modeled behavior is interesting or there is a novel aspect to the behavior or learning environment, observers are far more likely to dedicate their full attention. Attentional processes determine what is observed from the modeled behavior and what was extracted from it (Bandura, 1977). Many factors impact the amount and types of observational learning experiences that the observers are exposed to, for example, the characteristics of the modeled activities or the planned interactions between the observers.

Bandura (1977) implies that the functional value of the behaviors displayed will determine the effectiveness of the learning. In order to accomplish this, Bandura (1977) explains that the observers must represent the modeled behaviors in memory as symbolic images that can be recalled in the future when needed. He goes on to describe that there are two representations for modeled behavior – imaginal and verbal and both are important in helping students to retain these behaviors.

**Retention.** Student learning will not be influenced by observational learning if they do not remember it (Bandura, 1977). The ability to remember modeled behavior, for recall in the future, requires the observer to store these behaviors in memory in symbolic form. Retention can
be affected by a number of factors, but the ability to retrieve the information and later act on it is vital to observational learning. Repeating key learning behaviors and stressing the importance of these behaviors is instrumental in making these behaviors become habits. Repeated exposure to modeled behaviors will result in enduring, retrievable images of the modeled performances.

In addition to storing symbolic images of the modeled behaviors, observers can create verbal codes for these same behaviors. Bandura (1977) explains that cognitive processes that regulate behavior are primarily verbal versus visual. Verbal codes like key words or concise labels are used by observers to remember a great deal of information in an easily stored form.

**Motor Reproduction.** Once you have paid attention to the modeled behavior and retained the information in the form of visual symbols or verbal codes, it is time to actually perform the behavior you observed. This is what Bandura (1977) refers to as the motor reproduction process. Further practice of the retained behaviors leads to adjustments, improvements and further skill development. To do this effectively, observers must organize their responses spatially and temporally based on the modeled behaviors they have stored. Through informative feedback during use of the recalled behaviors, observers will refine these learned behaviors and store them for future use.

Bandura (1977) posits that “ideas are rarely transformed into correct actions without error on first attempt. Accurate matches are usually achieved by corrective adjustments of preliminary efforts” (p. 28). Mistakes in the execution of recalled learned behaviors are signals to the SI Leader and students that corrective actions are required so that skill development can be refined.

Bandura (1977) states that “people usually achieve a close approximation of the new behavior by modeling, and they refine it through self-corrective adjustments on the basis of informative feedback from performance and from focused demonstrations of segments that have
only been partially learned” (p.28). Refinement of effective learned behaviors and the rewards experienced by the observer when using the behaviors will result in motivating observers to continue to use them.

Motivational. Finally, in order for observational learning to be successful, students have to be motivated to imitate the behavior that has been modeled. Most students are more likely to adopt modeled behaviors that result in outcomes that they value rather than those that have negative effects (Bandura, 1977). Reinforcement and punishment play an important role in motivation. While motivation through positive reinforcement can be highly effective, so can observing other students receiving some type of reinforcement. Likewise the same can happen when students experience some type of punishment or negative effect from using a new behavior or observing other students experiencing some type of negative effect. For example, if you see another student rewarded with extra credit for being to class on time, you might start to show up a few minutes early each day or if you see a student receive a bad grade on a test for not showing all of their work in solving a math problem, you will be inclined to take the extra time required to show all of your work the next time that you are solving a math problem. Furthermore, honest assessment in a non-punitive fashion is essential to support and motivate students (Hansman, 2009). Finally, students who have high perceived self-efficacy in their ability to control their own learning and to master their coursework achieve success and have a heightened motivation (Bandura, 1996).

Summary

Based on Bandura’s four steps of observational learning, if a student fails to reproduce a behavior modeled by the SI Leader, one of the following must be true: the student is not observing the relevant behaviors, the student is not effectively memorizing or coding the desired
behaviors, the student is not converting the behaviors stored in memory into the appropriate actions to be successful, or the student does not see the benefit of or reward for using the behavior. In addition, if the four steps above are successfully realized by the students participating in the SI sessions, their perceived self-efficacy to continue these learned behaviors will be strengthened. The importance of perceived self-efficacy is rooted in Social Learning Theory and has been documented by Bandura in many studies over the years (Bandura, 1986, 1989, 1990, 1993, 1995, 1996). A student’s efficacy beliefs will influence their aspirations and commitments to their goals, their level of motivation and perseverance to face difficulties, their resilience to adversity and the quality of their analytical thinking (Bandura, 1996). More importantly, these beliefs shape their career aspirations; the more they believe in their abilities to accomplish their goals, the more occupational options they consider possible, the better they prepare themselves educationally and the greater they persist in their academic coursework (Betz & Hackett, 1986; Lent, Brown, & Hackett, 1994). The use of Social Learning Theory is an effective lens through which an investigation of students’ experiences in SI programs can be studied.

Therefore, Bandura’s Social Learning Theory served as the theoretical lens for this research study, examining how students make sense of their experience in a SI program as they navigate a math intensive engineering technology course. The idea is that if students participate in a math-focused SI session, their perceptions of the why math is important as well as their self-confidence to succeed in future courses will change.

In conclusion, the next section of this paper includes an extensive literature review which is organized into the following relevant sections; supplemental instruction to examine the key characteristics that make SI sessions successful; making learning relevant to understand how the
SI assignments can be designed to include real-life problems, thus impacting the student’s motivation to learn; and finally, mentoring to examine the influence that a SI Leader’s modeled behaviors have on the students who participate in the SI sessions.
Chapter Two: Literature Review

College students face many academic challenges including the application of mathematics to solve real-life problems (DeCorte, 2004; Micari & Light, 2009; Verner, Aroshas, & Berman, 2008; Zinser, 2012). More specifically, many cannot connect math concepts to applications within their academic disciplines. This disconnect can be partially tied to their high school experience (Hoyt & Sorensen, 2001) where instruction becomes segmented and many students become less engaged in the learning process (Malm, Bryngfors, & Mörner, 2012; Wright, Wright, & Lamb, 2002). Their ability to investigate interconnections between what they learn is limited because the teacher has too much material to cover and not enough time (Daggett, 2005). As a result, college students frequently ask why they need to know math, even though most technical disciplines require a solid foundation in algebra or higher and many students enter college unprepared for the study of mathematics (Corbishley & Truxaw, 2010; McCormick & Lucas, 2011). To complicate matters, pass rates in math intensive courses are low (Boughan, 1996). To assist students, many colleges offer math tutoring services. However, the tutoring services alone, while helping students who take advantage of them, have not shown enough of a positive impact on student math performance. An instructional intervention is required to assist more students in applying math concepts within the courses of their chosen academic discipline (Verner, Aroshas, & Berman, 2008).

The instructional intervention that is investigated in this study is supplemental instruction (SI). SI provides assistance on an outreach basis in regularly scheduled out-of-class study sessions that begin the 1st week of class (Lockie & Van Lanen, 2008). A good SI program should provide help to students before they find themselves having trouble (Congos & Schoeps,
The math faculty, tutoring professionals, other discipline specific faculty and educational administrators will have to collaborate to create a successful program.

In addition, McCormick and Lucas (2011) posit that understanding mathematics bridges all subject areas, as well as the globalization of today’s society, and provides measures to effectively interpret, critically analyze, and evaluate data in both numeric and visual presentations. Further, Parkinson (2009) explains that students studying first year biotechnology have found problems in understanding and problem solving in mathematics (calculus) and chemistry. To complicate matters, at Tech College, more and more students taking the Accuplacer math assessment exam are placed into remedial math courses. Placement into remedial math delays students from being able to start classes in their discipline thus increasing their risk of leaving school in their first year. Tech College’s experience tells us that when students are not taking courses in their discipline, they get frustrated and have a higher likelihood of withdrawing.

Additionally, Verner, Aroshas & Berman (2008) documents that real-life applications should be integrated into basic mathematics courses in order to increase students’ motivation, connect mathematics to their disciplines and facilitate their understanding of the applications of the mathematical concepts. The skills learned in math class must be reinforced in discipline specific courses so that the students can see the link between math and their discipline. Steen (2007) suggests that without reliable contexts to connect the math skills to the application, many students only see math as a meaningless cloud of abstract symbols. The desired outcome of this SI program will make these important contextual connections and will give students confidence not only in their ability to succeed in math but in their ability to succeed in their chosen discipline. Academic administrators have a responsibility to assist in creating programs that
help students to succeed, to be retained and to eventually graduate. Therefore, the development of a SI program that contextually links math to the student’s discipline and helps them to achieve the higher level math skills required to succeed and persist to graduation is very important.

To be fully prepared to answer the research question, the following bodies of literature were reviewed: supplemental instruction, making learning relevant, and mentoring. There are many articles from well-known authors in all of these areas of research. This study first looks at what others recommend in implementing an effective SI program and what they have reported about their implementations. Further, making links between math and discipline specific courses is critical in getting students to understand the relevance of math. Applying math to solve “real-life” problems will assist students in making math relevant. Finally, effective SI programs typically start during week one (Arendale, 1997; Etter, Burmeister & Elder, 2000; Lockie & Van Lanen, 2008) and continue throughout the semester or quarter. This results in the SI Leader-student relationship becoming more of a mentor-protégé relationship. Since these relationships tend to be more informal and personal as time progresses, SI Leaders must be cognitive of the potential issues and biases that may arise, including their impacts on developing SI student’s autonomy, exercising their power over SI students, communicating honestly and candidly with SI students, and making the SI sessions accessible to all students who are interested in participating.

**Supplemental Instruction**

Supplemental instruction was first introduced by Deanna Martin at the University of Missouri – Kansas City in 1973. Unlike other academic support programs, SI targets high-risk courses versus high-risk students. A high-risk course is defined as a course where at least thirty percent of the students receive a D, F or W (Burmeister, 1996). There is no remedial stigma
associated with SI due to its focus on high-risk courses (Martin & Arendale, 1994), thus more students are apt to participate. Also, while students are strongly encouraged to attend the SI sessions, attendance is voluntary.

According to Martin and Arendale (1994), SI is designed to improve student grades in targeted courses; improve the attrition rate in those courses; and increase the graduation rates of students. To further describe SI, Burmeister (1996) offers that SI sessions 1) are tied to high-risk courses; 2) are non-remedial and open to all students in the targeted course; 3) are not tutoring sessions, but are supervised, small group collaborative learning sessions; 4) are facilitated by a student or professional, called the SI Leader, that has been deemed by the faculty member as competent in the course; and 5) are monitored by a SI Supervisor who evaluates the effects of SI sessions on student success in the targeted course. Finally, Maxwell (as cited in Wright, Wright & Lamb, 2002) explains that SI is 1) a form of group tutoring where the SI leader (usually a peer tutor) works closely with the instructor and the students who chose to participate; 2) designed to help students with the content as well as their competency in critical thinking and study skills; 3) designed to use peer tutors who have shown exceptional performance in the course for which they are the SI Leader and have demonstrated good study skills and high GPAs; 4) design so that the SI Leaders attend the classes, take notes and complete assignments with the enrolled students; 5) designed to provide at least two 50-minute SI sessions per week, scheduled at a time that is convenient for most students; and 6) designed to utilize SI Leaders that are well trained in learning theories, methods of tutoring and collaborative learning techniques. While the above descriptions do differ slightly, there are many commonalities. To illustrate the successes and lessons learned regarding SI, examples are provided below.
Many researchers have found positive effects for students who attend SI sessions, including higher final grades and fewer lower grades and withdrawals in the targeted course (Arendale, 1997; Congos & Schoeps, 1993; Fayowski & McMillian, 2008; Ogden, Thompson, Russell & Simons, 2003; Shaya, Petty & Petty, 1993), higher GPAs (Ramirez, 1997), increased persistence (Arendale, 1997; Hurley, Jacobs, & Gilbert, 2006; Ogden et al., 2003), application of study and note taking skills, acquired in SI sessions, in subsequent courses (Jarrett & Harris, 2009) and improved graduation rates (Arendale, 1993; Zerger, Clark-Unite, & Smith, 2006).

Congos and Schoeps (1993) performed a study to determine if SI really works and in particular looked to determine if higher final grades and fewer lower grades and withdrawals were noted for SI participants. Specifically, they looked at the SI program implemented at the University of North Carolina at Charlotte (UNCC) and found that there were three main goals that they hoped resulted in better grades for SI participants.

1. Building complete and accurate notes – as a group, students construct a comprehensive set of notes from the contents of the previous lecture and any reading assignments. The SI Leader records their inputs on the board in a format modeling effective note taking.

2. Forming possible exam questions and answers – after the notes are finalized, students are ask to develop exam questions and associated answers. This process assists them in developing skills that relate information and how to form coherent questions and answers. The process helps student to move from just memorizing information to understanding it.

3. Performing a post-test survey – after receiving their corrected test, students exam the correct answers and identify the study skills that they used to achieve the correct answer. Conversely, students look at the incorrect answers to determine why they got the answer
wrong and to determine what study skills might help them to achieve correct answers in the future.

The results of this implementation were positive with 82.25% of SI students achieving an A, B, or C versus 62.07% for non-SI students and 17.75% of SI students achieving a D, F, or W compared to 37.93% for non-SI students.

It has been shown that when students achieve better grades, they persist at higher rates. Noel and Levitz (as cited in Arendale, 1997) showed that students with higher GPAs persisted at higher rates than their counterparts with lower GPAs. For example, students with GPAs between 2.00 and 2.99 persisted at a rate of 78%, with 22% dropping out. Since it has been demonstrated that SI programs have increased student grades for targeted, high-risk courses, it can be implied that overall GPAs will increase thus resulting in increased persistence.

Ogden, Thompson, Russell and Simons (2003) illustrated this in their two year study of the short- and long-term impact of SI at a large southern university. The SI sessions were offered for a high-risk political science course and the SI Leaders were graduate students who had successfully completed the course and who attended the SI Leader training sessions. The SI sessions were started in the first week of class and continued throughout the term. As designed, these sessions were voluntary. The activities performed in each session varied based on the specific needs of the SI participants and the SI Leaders facilitated the learning and modeled how successful students think about and process course content.

At the end of the two-year study, Ogden et al. (2003) showed that students receiving SI persisted at a higher rate than non-SI students. This especially held true for students who were classified as “conditional”, meaning that they entered this university in a conditional status.
From the data, in the spring of 1997, conditional SI students persisted at a rate of 88.3% versus 65.2% for conditional non-SI students.

In addition to students achieving higher grades and higher GPAs and thus increased persistence, graduation rates have been shown to improve for students participating in SI sessions. Arendale (1993) illustrated this in his study of the effectiveness of SI across the US. The data that he used was submitted each year to the University of Missouri – Kansas City, by over 100 institutions using SI. The study looked at the three claims that SI results in students achieving higher grades, lower percentages of D’s and F’s, and higher rates of graduation. After compiling and using statistical techniques to analyze the data, it was found that students participating in SI sessions graduated at a higher rate than non-SI students. This was especially true for first-time, first-year students who participated in SI, as they graduated at a rate of 46.0% after four-years compared to 30.3% for non-SI students.

In conclusion, since much of the SI research to date has already shown improvements in grades, persistence rates and graduation rates, more research is needed regarding the perceptions of students who have participated in these SI sessions. Further, much of the research to date has focused on high-risk math or sciences courses and not high-risk, discipline specific courses. Therefore, this study adds to the existing literature by documenting the student’s perceptions regarding their lived experiences in the SI sessions designed to support their learning and application of math concepts in a discipline specific course. These SI experiences will hopefully help the students to answer the question, “Why do I need to know math?” by showing them the relevance of math to their discipline.
Making Learning Relevant

In order for a SI program to be successful, making learning relevant is an important part in helping students to contextualize the math concepts to their discipline of study. Relevancy will also help in motivating students to succeed (Bandura, 1997; Crumpton & Gregory, 2011; Jenkins, 2011). This is especially true in motivating students studying Science, Technology, Engineering and Math (STEM) disciplines. It is important to develop connections between students’ everyday lives and science so that they have tangible reasons for continuing the lifelong learning of science (Jenkins, 2011). The same can also be said for math. Furthermore, Gambrell (2011) posits that students are more motivated when tasks and activities are relevant to their lives, for example to their interest in their discipline.

Even when connections to real-life are made there is still the challenge of breaking down the walls that have isolated math from “real-life”. These walls were most likely created during the student’s primary and secondary education. They can mostly be attributed to high school where instruction becomes segmented and many students become less engaged in the learning process resulting in less effective learning because the teacher has too much material to cover and not enough time (Daggett, 2005). Therefore, higher education must develop real-life connections that motivate students to actively engage in applying math concepts to their discipline. If students struggle with these subjects due to lack of connections and relevancy, they get frustrated and create a mindset that these subjects are “hard” (Crumpton & Gregory, 2011). Compound this with just one experience where a teacher makes a comment about math or science being difficult and the negative attitude that results is carried with the student throughout the remainder of their primary and secondary education and into their collegiate education.
Faculty sees these negative student attitudes all the time (Hemmings, Grootenboer & Kay, 2011) and it is easy for these faculty members to say “they’re college students now so they have to figure out how to learn this stuff.” However, faculty needs to take a different approach like asking students why they dislike math. Many students will respond with “because it’s hard” or “I’ve never been good at math.” This becomes problematic, from a student success point of view, since many degree programs require the completion of at least one math course and in most cases multiple math courses (Corbishley & Truxaw, 2010). But, many students enter college unprepared for the study of math, a trend that is becoming more widespread, leaving institutions with the task of providing students with the requisite math skills through remedial courses (Bahr, 2008).

In order to improve the math performance of students, the skills learned in math class must be reinforced in discipline specific courses. Ultimately, if successful, an SI program focused on connecting math concepts to applications in their discipline, will make math relevant and will give students confidence not only in their ability to succeed in math but in their ability to apply math within the context of their discipline.

In this study, with a focus on connecting math concepts to complex applications in an engineering technology course, the researcher investigated the student’s perceptions of the importance of these connections and whether making math relevant to the student’s discipline makes a difference.

**Mentoring**

An important part of the SI program is the role of the SI Leader. This SI Leader is a peer who has successfully taken the targeted course in the past. This SI Leader attends all classes, performs all assignments and then facilitates the SI sessions. As a result, the SI Leader becomes
more of a mentor to the SI participants, responsible for modeling behaviors that students will learn from. It is important that the training provided to the SI Leader includes a discussion of the role of a mentor and the issues and concerns that may arise. Johnson (2008), a leading researcher of mentoring, suggests that faculty members in higher education are increasingly called to engage in thoughtful and intentional developmental relationships with students. The implementation of a SI program will produce these types of relationships between the SI Leaders and the students. These SI Leader-student relationships will be very much like a mentor-protégé relationship that can provide both the mentor (SI Leader) and protégé (student) with many benefits. These benefits include increased visibility and gratification for the mentor and contextual links between math and their discipline, challenging and relevant work and acquisition of good study skills, as modeled by the SI Leader, for the protégé. While there are many benefits for both mentors and protégées, there are a variety of ethical considerations to be considered (Anderson & Shore, 2008; Hansman, 2009; Moberg, 2008; Warren, 2005).

Effective SI programs typically start during week one and continue throughout the semester or quarter, resulting in the SI Leader-student relationship becoming more of a mentor-protégé relationship. Since these relationships tend to be more informal and personal as time progresses, SI Leaders must be cognitive of the potential issues and biases that may arise. There are four ethical concerns that SI Leaders must be aware of. They are autonomy, power, communications, and accessibility. These considerations combined with the fact that the mentor-protégé relationship can become quite complex, result in the protégé being vulnerable to exploitation (Anderson & Shore, 2008). The following four sections discuss the potential implications of each of these ethical considerations and some recommendations for addressing each.
Autonomy. In this study, autonomy is defined as academic independence. Helping the protégé (SI participant) to achieve academic independence is an important task for the mentor (SI Leader). This is especially true for undergraduate students who are generally more dependent on parents, friends and mentors for their emotional support, sense of direction in life, and even the structure and prompts that get them through the routine of daily life (Anderson & Shore, 2008).

In a SI program, the mentors not only have the responsibility to help the students with the application of math concepts, but also to help their protégés to function autonomously within their program of study. This task becomes more difficult as the relationship progresses, since the mentor becomes much more vested in the success of his/her protégés. The protégé’s future performance in applying math concepts within the context of their discipline is a direct reflection on the mentor’s ability to effectively tutor students (Johnson, 2008) and to demonstrate good study behaviors for student participants to learn. This may blur the mentor’s capability to effectively evaluate the ability of the protégé to think autonomously. The mentor and protégé must be cognitive of this, always working towards ensuring that the protégé truly achieves independence and confidence in their ability to apply the math concepts. Since the SI program is only be offered in high-risk courses, the protégés only have a limited amount of time to improve their math skills in order to achieve success in their program of study. The student knowing in advance that that they will lose their mentor becomes a powerful motivation for the student to acquire the skills being offered by the SI Leader in a timely manner (Anderson & Shore, 2008).

Power. Mentors, by their institutional or societal roles, have power that can help or harm their protégés (Hansman, 2009). At the undergraduate level, where protégés do not typically have the life experiences that graduate level students have, there is a level of inherent trust that the protégés have in their mentors. Anderson & Shore (2008) assert that the naïveté of
undergraduate protégés about power and trust makes them highly vulnerable to exploitation by an unscrupulous mentor. For example, mentors have the power to make the problems given during the SI session too difficult, further discouraging the protégé and potentially causing them to walk away. On the other hand, the mentor can give the protégés easy problems, providing a false sense of mastery of the application of the math concepts. So there is a delicate balance that the mentor must achieve between the difficulty of problems assigned with the ability of the protégés math skills. This is one of the reasons why SI Leaders are required to attend the classes, take notes and complete assignments with the enrolled students and to work closely with faculty to plan the SI sessions.

Also, an important component in an effective SI program is the mentor’s ability to make important contextual links between math application and the topics discussed in the high-risk course. Making these connections is vital to helping the students improve their skills in applying math to problems in their discipline courses and to increasing their motivation to continue their participation in the SI sessions. Unbeknownst to the protégés, mentors have the power to make very relevant connections to real-life applications by coordinating the examples discussed and problems given to protégés with the faculty. The mentors selected to facilitate the SI sessions must carefully consider how their power can be helpful or harmful to the students they are working with, and they must consciously use that power in positive ways (Hansman, 2009) to help the protégés improve their understanding of the relevant math concepts and to develop future behaviors that are required to be successful in subsequent courses.

**Communications.** In order to develop a protégé’s autonomy and to steer clear of any inappropriate power influence over a protégé, a mentor must be willing to have frank and honest communications with each protégé. One of the most important characteristics of SI Leaders is
the ability to communicate empathy, respect and compassion to protégés (Johnson, 2003).

During the first SI session, there should be discussion of the roles, goals and outcomes of the SI program. This early discussion may not be easy since there has been little to no interaction between the mentor and protégés, therefore the protégés have to trust in someone they may not know. However, the SI Leaders must define their roles as mentors and the expectations they have of their protégés. Not doing this upfront can lead to future communications that are uncomfortable for the mentor and protégé that may discourage the protégé from continuing in the SI program.

Since the mentor-protégé relationship does become more personal as time passes, it is important for the mentor to stress to their protégés that they will be providing very honest and candid feedback on their ability to apply math concepts to discipline specific problems throughout the SI program. An honest evaluation, including constructive feedback, in a non-punitive way is essential to support their protégés (Hansman, 2009). Moberg (2008) stresses the importance that “the mentor must provide feedback on how well the task is being mastered” (p. 96). Mentors must take responsibility for these communications and at the same time be good listeners, reflecting on their protégés questions or concerns and then responding and guiding their protégés to find the answer themselves or as a small group. Communications with protégés that include constructive criticism, cooperative two-way conversations and that are honest and candid are a key characteristic to a successful mentor-protégé relationship and thus are important to a successful SI program.

Accessibility. SI programs must strive to provide equal access to all students. This can be difficult, considering the resources required, the hectic schedules that some undergraduate students have, and the limited number of qualified mentors that are available. Regardless, care
must be taken to afford access to all students to avoid any claims of discrimination. Setting an expectation for undergraduates to participate and receive SI, but failing to provide it may cause frustration with the institution, program, or faculty (Anderson & Shore, 2008). Further compounding this problem is the large numbers of students at the undergraduate level, resulting in the increased demand for qualified mentors willing to participate in a SI program.

Failing to offer a SI program to all students can lead to students, not participating, who feel left out and others, participating, who feel that they have special needs. This may result in both groups of students feeling isolated from their peers, causing them to feel that they will never acquire the math skills needed to succeed. For these reasons, the SI program must be offered to all students and not just a select few. This is why the SI program is designed to target high-risk courses and is open to all students in these courses. Also, SI sessions should be scheduled at times that afford access to the largest number of students (Martin & Arendale, 1994).

Four key ethical considerations (autonomy, power, communications and accessibility) regarding mentoring within a SI program have been discussed. Each of these considerations must be understood by the SI Leaders or mentors in order to increase the likelihood of having a successful SI program.

In conclusion, the SI Leaders play a pivotal role in the success of SI sessions. Their understanding of the role of mentor is critical to how they conduct the SI sessions and how they interact with the student participants. The SI Leader is responsible for modeling behaviors that students can acquire, refine and master during the academic term. These behaviors will help students to become autonomous and, more specifically, to understand how to apply math concepts to complex engineering technology problems. Successful transfer of these behaviors, taking into account the impacts of power, communications and accessibility as discussed above,
will assist in helping the SI participants to be successful in this high-risk course as well as in future math intensive courses.

**Conclusion**

With many students entering college unprepared for the rigor of college math, institutions must provide academic support in order to assist students in persisting to graduation. According to the literature, supplemental instruction (SI) programs assist students in achieving higher grades, higher GPAs and improved persistence and graduation rates. Students will also improve studying, note taking and problem solving skills. An effective SI program focusing on the application of math concepts within discipline specific courses is one way to provide the critical academic support that students need. If implemented properly, a SI program can provide the needed links between math and a discipline so that the math application becomes relevant.

While many SI programs have been implemented in support of high-risk math and science courses (Fayowski & MacMillan, 2008; Lockie & Van Lanen, 2008; Parkinson, 2009; Shaya et al., 1993; Verner et al., 2008; Wright et al., 2002), very little research has been done applying SI to discipline specific courses (Etter, Burmeister & Elder, 2000; Jones & Fields, 2001; Oja, 2012; Parkinson, 2009). More research on SI applied to high-risk discipline specific courses is needed to fully understand the impact on student persistence and graduation rates.

In order for the SI program to be successful, the SI Leaders or peer tutors who facilitate the SI sessions must be trained properly. Since they will act as mentors to the SI participants, care must be given to training these SI Leaders with special attention focused on their role as a mentor. This is especially true if the targeted high-risk course is at the undergraduate level as mentors can have more influence over these younger, more impressionable students.
In closing, while SI can provide many academic benefits to students and institutions, the larger benefit is realized when students persist to graduation and enter the workforce. Their persistence to graduation will result in securing higher paying jobs and becoming more productive citizens. The U.S. is in need of more qualified and technically trained people to meet the needs of the new global economy and SI is a strategy that can be used to assist students in persisting, thus becoming part of this workforce.

This study investigates how Tech College students make sense of and attach meaning to the SI program designed to connect math concepts to their engineering technology course. It is through an understanding of their experiences that SI programs can be designed to be more effective in educating students on how to apply math concepts to complex engineering technology problems.
Chapter Three: Research Design

Research Question

The following question was used to focus this research.

1. How do Tech College students make sense of and attach meaning to the SI program designed to connect math concepts to their engineering technology course?

The purpose of answering this question was to gain an understanding of the perceptions that students, participating in the SI program, have regarding their experiences in the program and how they make sense of these experiences. While many SI programs have been implemented in support of high-risk math and science courses (Fayowski & MacMillan, 2008; Lockie & Van Lanen, 2008; Parkinson, 2009; Shaya et al., 1993; Verner et al., 2008; Wright et al., 2002), very little research has been done evaluating the application of SI to discipline specific courses (Etter, Burmeister & Elder, 2000; Jones & Fields, 2001; Oja, 2012; Parkinson, 2009). Further, there has been no research conducted that looks at the student perceptions and sense making of participating in a SI program. Research on SI applied to high-risk, discipline specific courses and the perceptions of students who have participated, is needed to fully understand the student’s experiences and their thoughts on the impact of the SI session on their performance in these high-risk courses. This study contributes to the existing literature by providing insights on student’s perceptions of the impact of a SI program designed to link math concepts to engineering technology applications through their lived experiences.

Methodology

This study employed a qualitative research approach designed to capture an understanding of the lived experiences of engineering technology students who participate in a SI program focused on connecting important math concepts to complex engineering applications.
This research regarding the implementation of a SI program, as experienced by the students and interpreted by the researcher, seeks to make sense and attach meaning to the lived experiences of a particular group of students who participate. The use of a qualitative approach best fits this research since this approach focuses on collecting data in a natural setting sensitive to the people under study and the data analysis attempts to establish patterns/themes (Bogdan & Biklen, 2003). A qualitative approach employs a constructivist-interpretivist paradigm with the main characteristic being the interaction between the investigator and the object of the investigation (Ponterotto, 2005). The researcher and the participants co-construct findings from their interactive dialogue and interpretation (Ponterotto, 2005). Further, qualitative research does not seek to prove or disprove hypotheses, but instead looks to develop theories that emerge from understanding the lived experiences of the participants (Bogdan & Biklen, 2003).

The basis of qualitative research is concerned with the quality and texture of the experiences of the participants and looks to describe and explain events that they have experienced (Larkin, 2013). Specifically, qualitative researchers are interested in studying people in their own environments. As described in Bogdan and Biklen (2003), qualitative research has five distinct features: naturalistic, descriptive data, concern with process, inductive, and meaning. First, naturalistic refers to the importance of the actual setting of the research and the researcher’s involvement as the collector of data within that context. Second, descriptive data or data in the form of words or pictures is collected rather than numbers. Third, concern with process refers to the fact that qualitative researchers are more concerned with process than with outcomes or products. Fourth, inductive refers to how qualitative researchers analyze data, looking at each particular data separately and then grouping like data together to develop emerging themes rather than collecting data to prove or disprove a hypothesis. Finally, meaning
refers to the researcher trying to understand how different people make sense of their lives or trying to understand the participant’s perceptions of their lived experiences.

More specifically, there is a form of qualitative research called phenomenology, where researchers attempt to understand the meaning of events and interactions of ordinary people in particular situations (Bogdan & Biklen, 2003). Phenomenology employs an *intersubjective* approach, meaning that people perceive the world through their engagement in it and its meaning is a function of their relationship to it (Larkin, 2013). There are two phases to a phenomenological inquiry; the first is the descriptive or transcendental phase; and the second is the hermeneutic or existential phase.

Edmund Husserl, a German philosopher, considered to have established the field of phenomenological inquiry, explained that phenomenology involves the examination of human experience (Figal, 2009). The key premise of Husserl’s thoughts on phenomenology was that there is only a phenomenon when there is a human being there to experience the phenomenon (Sadala & Adorno, 2002). Further, he believed that by understanding someone’s experiences in great depth, one could come to understand the essential qualities of that experience (Smith, Flowers & Larkin, 2009). Husserl believed that understanding the essential features of the experience would transcend the particular circumstances and would illuminate the experience for others (Smith, Flowers & Larkin, 2009).

However, two students of Husserl, Martin Heidegger and Maurice Merleau-Ponty, further defined phenomenology as having a hermeneutic or existential component. Heidegger is credited with moving phenomenology from a transcendental focus to a hermeneutic or existential focus (Smith, Flowers & Larkin, 2009). Heidegger firmly believed that a person was a worldly, person-in-context, that one’s lived experiences are connected and related to the lived experiences
of others, thereby introducing the phenomenological concept of intersubjectivity or the shared, overlapping and relational nature of our engagement in the world (Smith, Flowers & Larkin, 2009). He conceived human beings as being thrown into a world of objects, relationships, and language. In Being and Time, Heidegger speaks of “Dasein” or “the accessibility of the world” or “in-the-world,” and the concept of disclosedness which Heidegger describes as the key to Dasein and provides for the ability to discover (Figal, 2009). Consequently, interpretation of people’s meaning-making in the context of Dasein is a central part of Heidegger’s definition of phenomenological inquiry.

Also sharing Heidegger’s focus on a more contextualized phenomenology, Merleau-Ponty developed a different approach by describing the embodied nature of our relationship to the world resulting in the primacy of our individual perspective of the world (Smith, Flowers & Larkin, 2009). He believes that perceptions of our experiences are always influenced by our past experiences (Figal, 2009), therefore resulting in our being-in-the-world as always perspectival, temporal and in-relation-to something (Smith, Flowers & Larkin, 2009). In interacting with the world, with both beings and things, a person observes these beings and things from different perspectives depending on the interaction in space and time (Sadala & Adorno, 2002).

In addition, Smith, Flowers and Larkin (2009) further define a specific method of phenomenological inquiry called Interpretive Phenomenological Analysis (IPA). An IPA is concerned with examining how a phenomenon appears with the researcher responsible for making sense of this appearance (Smith, Flowers & Larkin, 2009). Further, an IPA pursues the understanding of participants in a particular context, understanding their personal perspectives and then moving towards more general claims (Smith, Flowers & Larkin, 2009). IPA focuses on the meaning that participants impress upon the phenomenon based on past lived experiences.
(Smith, Flowers & Larkin, 2009). Since this study looks to understand the phenomenon of participation by a particular group of students in a SI session as interpreted by the researcher, an IPA research approach was selected.

There are three key characteristics of an IPA that make it the best approach for this study: phenomenology, hermeneutics, and idiography.

**Phenomenology.** All phenomenological research designs, including IPA, seek to understand the lived experiences of the participants and how participants make sense of the experience (Smith, Flowers & Larkin, 2009; Smith, 2011). The understanding of lived experiences requires a complex understanding of the perspectives of the each participant as influenced by their past experiences and how they are situated in the world (Smith, Flowers & Larkin, 2009). According to Husserl (as cited in Smith, Flowers & Larkin, 2009), a phenomenological inquiry should examine the phenomenon as it occurs and in its own terms, but needs to avoid fitting the results into the researchers pre-existing categorization system. In addition, Heidegger (as cited in Smith, Flowers & Larkin, 2009), stresses that human beings are always perceptival, always temporal, and always ‘in-relation-to’ something, confirming that interpretation of people’s meaning-making is a critical characteristic of phenomenological inquiry. The primary goal of a phenomenological design is to reduce individual experiences of a particular phenomenon to a description of a more universal principle (Bogdan & Biklen, 2003).

The student participants in the study voluntarily participated in SI sessions designed to assist them in applying important math concepts to problems related to their engineering technology course. The SI sessions focused on the topics discussed in class and were facilitated by a SI Leader. The SI Leader attended all classes with the students and then, in collaboration with faculty, designed SI assignments relevant to the topics discussed. The assignments were
focused on applying important math concepts to solve complex engineering problems. As student participants progressed through the academic term and attended multiple SI sessions, they were forming perceptions and were trying to make sense of and apply meaning to these SI sessions.

**Hermeneutics.** An IPA research design recognizes that the researcher interprets what the participants say and mean as a part of the analysis (Smith, Flowers & Larkin, 2009). This hermeneutic or interpretive influence is embraced in the IPA design approach. Gadamer (as cited in Smith, Flowers & Larkin, 2009), posits that the researcher must be aware of their biases related to the phenomenon in order to conduct a meaningful analysis. He goes on to explain that there is a temporal effect on the interpretation that is the interpretation will be influenced by the moment that the interpretation takes place. Further, there is what Smith, Flowers and Larkin (2009) call a double hermeneutic characteristic in an IPA approach, meaning that the researcher is trying to make sense of the participant’s experiences at the same time that the participants are trying to make sense of their own experiences.

As a result of the understanding described above, the research design employed an interview protocol that used a predetermined set of questions. The questions were designed to capture data that is relevant to the primary research question, including the student’s perceptions of the SI sessions, the relevancy of the assignments used during the SI sessions, and the influence of the SI leader in facilitating the SI sessions. While the above were the goals for collecting relevant data, the researcher understood that the interviews may uncover other topics that are important in understanding the student’s perceptions. Therefore, the interviews were semi-structured so to allow for divergence from the above stated goals. Finally, it was understood that
the interpretation of the data collected by the researcher would influence the data analysis, so the researcher took care to disclose any biases that may exist based on his past experiences.

**Idiography.** Idiography focuses on the particular and IPA is committed to understanding a particular experience from the perspective of particular participants in a particular context (Smith, Flowers & Larkin, 2009). This approach emphasizes the importance of looking at each case, or participant, separately and analyzing their responses completely before looking for patterns and themes (Smith, Flowers & Larkin, 2009). Looking at each case individually can uncover things that were not anticipated or can uncover flaws in previous research findings (Smith, Flowers & Larkin, 2009). Thus Smith, Flowers and Larkin (2009) posit that the analysis of the individual brings us closer to key characteristics of the general.

As mentioned above, this research design employed interviewing techniques that resulted in the collection of meaningful data. Understanding the IPA characteristic of idiography, the researcher understood the importance of analyzing the data collected from each participant individually and thoroughly before looking for patterns and themes between all participant responses.

**Site and participants.** The site of this study was a suburban technical college, referred to in this study simply as Tech College. This institution is a private, non-profit, career and technical college offering 39 associate’s degrees, 15 baccalaureate degrees and 3 professional master’s degrees. Tech College is accredited by the New England Association of Schools and Colleges (NEASC), Commission on Institutions of Higher Education (CIHE) and enrolls approximately 3000 students. This institution was founded in 1940 as a trade school and over the past 75 years has developed into a NEASC accredited college offering undergraduate and graduate studies. This site was chosen for three reasons. First, it offers multiple associate level and bachelorette
level degrees in engineering technology. Second, it has a diverse student population in terms of academic readiness and math preparedness. Third, the researcher had access to engineering technology students at this institution, through the Tech College Institutional Review Board (IRB) approval and due to his professional affiliation with the college.

The participants in this study included four students taking a sophomore-level Mechanics of Materials course. This is deemed a high-risk course due to the high number of students who have to repeat the course, who get low grades in the course or who withdraw from the course. The participants were volunteers from the cohort of students enrolled in this course. All students who were enrolled in this course were asked to volunteer for this study by agreeing to partake in three in-depth, semi-structured interviews with the researcher.

**Data collection.** In order to obtain a rich, detailed, first-person account of the participant’s experiences, twelve in-depth interviews were conducted. These interviews were in-person, semi-structured, one-on-one interviews that allowed participants to tell their stories, to speak freely and reflectively, and to develop their ideas and express their concerns at length (Smith, Flowers & Larkin, 2009). Interviews allow the researcher and participant to engage in a dialogue that can be modified or redirected based on participant responses in order for the researcher to capture rich and deep data regarding the participant’s experiences (Smith, Flowers & Larkin, 2009). Participants were treated as the experts by using open-ended questions (Bogdan & Biklen, 2003). This approach established an environment where the participant is the one that knows and the interviewer is the one that learns. The selection of the physical environment was important as well, so that the participant were not hesitant to speak and share ideas (Creswell, 2007). Creating this environment tells the participant that you care and respect
their thoughts and want to hear their stories. This resulted in capturing rich data regarding their SI experiences.

An interview protocol (Appendix A) was developed and used to ensure that the interviews were consistently conducted, that participants were assured that their responses were treated confidentially (Bogdan & Biklen, 2003), and that the questions asked during the interview were narrowing of the central question of the research study. Seidman’s (2013) three-interview series model was used. This model called for three interviews to be performed with each participant. The first interview explores the participant’s life history with respect to the research topic (Seidman, 2013). In this interview, the researcher explored the math history of each participant looking to understand their previous math experiences. This initial interview was no more than 60 minutes in duration. The second interview focused on collecting detailed data of the lived experiences of the participants based on the phenomenon being studied (Seidman, 2013). In this interview the researcher directed questioning to collect data regarding the specifics of the participant’s experiences in the SI sessions. The third interview asked participants to make meaning of the lived experiences during the phenomenon being studied (Seidman, 2013). In this interview the researcher asked participants to review the transcripts from the first two interviews and to reflect on their experiences in the SI sessions ensuring that the researcher captured their experiences accurately. Making meaning of something requires participants to look at how past experiences in their lives have interacted to bring them to their present state (Seidman, 2013).

The researcher used a digital recorder to record the interviews and ensured that all digital files related to the interviews were kept in a password-protected digital folder. The researcher
handled all data collected carefully to ensure that participant anonymity is maintained throughout the process.

**Data analysis.** Data collected in this study was abundant and required a complex process of analysis. Data analysis involved working with the data, organizing them, breaking them into manageable units, coding them, synthesizing them, and searching for patterns (Bogdan & Biklen, 2003). The process of analysis in this study included transcribing each interview, reading and re-reading each transcript, making annotations on each transcript, developing emerging themes for each transcript, and then looking for patterns across all transcripts. This process is a joint product of the participant and the researcher (Smith, Flowers & Larkin, 2009). Analysis is an iterative process to be completed in six steps, starting with review and interpretation of each individual transcript and ending with an interpretive analysis of all transcripts resulting in a rich description of the participant’s experiences in the SI sessions and meaning-making of those sessions.

**Step 1: Transcription and reading and re-reading.** The analysis started with the transcription of a single participant’s data. The researcher used rev.com to transcribe the audio files collected during the interviews. The researcher read and re-read the transcript and also listened to the audio recording of the interview to hear the tones and nuances in the participant’s voice (Smith, Flowers & Larkin, 2009). This step helped the researcher to make the participant the focus of the analysis. Smith, Flowers, and Larkin (2009) note that many people tend to read and summarize information in short periods of time, however they explain the importance of slowing down and actively engaging with the data. During this repeated reading of an individual transcript, a model of the interview developed and the researcher gained a detailed understanding of the narratives.
**Step 2: Initial note taking.** Next, the researcher re-read the transcript and took notes, documenting descriptive comments first. The researcher used MAXQDA to capture all notes. MAXQDA was used to organize, evaluate, code, annotate and interpret all the data that was collected in this study. Descriptive commenting looks at key words, phrases, and explanations that the participant uses to describe their experiences (Smith, Flowers & Larkin, 2009). The researcher then re-read the transcript and made linguistic comments paying close attention to pronoun use, pauses, laughter, and use of metaphors. In this phase, the researcher also listened to the audio recordings to account for participant pauses, laughter and other verbal cues. Use of metaphors can be a powerful component in the analysis as they typically link descriptive comments to conceptual comments (Smith, Flowers & Larkin, 2009). Finally, the researcher re-read the transcript and made conceptual comments. This level of commenting is more interpretive and attempts to document the participant’s overarching understandings of the matters that they are discussing (Smith, Flowers & Larkin, 2009).

**Step 3: Developing emergent themes.** Once commenting was complete, the researcher now had a larger data set including the original transcript and the descriptive, linguistic and conceptual comments. From this larger data set, the researcher looked to identify developing emergent themes. Identifying these emergent themes requires a focus on discrete slices of the transcript in conjunction with what was learned during the initial note taking step (Smith, Flowers & Larkin, 2009). The key objective in this part of the analysis was to take sections of the transcript and the associated researcher’s notes and to turn them into concise statements that capture the essence of the section. These emergent themes are typically expressed as a phrase that captures the particular in terms of the participant’s comments, but that also captures the researcher’s interpretation of a conceptual understanding of the section (Smith, Flowers &
Larkin, 2009). The result of this step in the analysis included a more detailed description and interpretative understanding of the transcript, with identified emergent themes organized in the order in which they occurred.

**Step 4: Searching for connections across emergent themes.** In this step of the analysis, the researcher created a mapping of how all of the themes fit together (Smith, Flowers & Larkin, 2009). The goal of this step was to develop a structure to define all of the most important aspects of the participant’s transcript. This was accomplished by creating a list of themes and reviewing them and moving them around into groups that are related. Once the themes are grouped, the researcher identified super-ordinate themes or overall themes that capture the essence of a grouping of like themes. There are many ways to accomplish this as defined by Smith, Flowers, and Larkin (2009) and include abstraction, subsumption, polarization, contextualization, enumeration and function. A combination of these techniques was used by the researcher in identifying the emergent themes from each transcript. The resulting groups of themes was documented in a table which identified the page/line of each theme and researcher notes regarding each theme. It is important that the researcher document the process used in this step of the analysis (Smith, Flowers & Larkin, 2009) as it will lend credibility to the eventual findings.

**Step 5: Moving to the next case.** Once the researcher completed the analysis of the first transcript using the steps noted above, the next step was to repeat the process for each of the remaining transcripts. The researcher treated all subsequent transcripts independent of any previously reviewed. Smith, Flowers, and Larkin (2009) stress the importance of treating each case on its own terms and bracketing the emergent themes from the analyses of previous cases.
This is in keeping with the idiographic characteristic of IPA. The researcher repeated this step for all four transcripts.

**Step 6: Looking for patterns across cases.** The final step in the data analysis process required the researcher to look at the data analysis of all transcripts together to look for patterns in the data. The researcher reviewed all individual themes and sub-ordinate themes looking for patterns across the entire data set. Smith, Flowers, and Larkin (2009) suggest that themes and super-ordinate themes from an individual case may also represent instances of higher order concepts that multiple cases share. The result of this step was the creation of a table detailing all identified themes and super-ordinate themes with verbatim passages from each participant to illustrate each theme.

**Validity and Credibility**

Qualitative researchers would assert that the validity and credibility of a qualitative research project is important, but should be evaluated in relation to criteria recognized as appropriate to it (Smith, Flowers, & Larkin, 2009). However, some qualitative researchers have contended that validity is not applicable to qualitative research, but they also realize that there is a need for some process to check or measure the quality of their research (Golafshani, 2003). That said, validity and credibility in this study was assessed using Yardley’s criteria as defined in Smith, Flowers, and Larkin (2009). These criteria include four key characteristics: *sensitivity to context, commitment and rigor, transparency and coherence, and impact and importance.*

**Sensitivity to context.** *Sensitivity to context* was realized in this study in multiple ways. First, when developing the interview schedule and then conducting the interview, the researcher showed empathy, put the participant at ease and took caution in negotiating the intricate power-play between the research expert (researcher) and the experiential expert (participant). By
developing a good interview schedule and focusing on the above characteristics when interviewing each participant, sensitivity to context was realized. Next, during the analysis process the researcher immersed himself in the data, being disciplined in letting the participant’s account naturally unfold and taking care in what themes were identified from it. Finally, any themes that were identified during the data analysis were supported by verbatim quotes from the participants resulting in validity and credibility in the findings. According to Smith, Flowers, and Larkin (2009), a good IPA study will always include verbatim quotes to support the arguments being made, thus giving the participants a voice in the findings and allowing the reader to verify the interpretations being made by the researcher.

**Commitment and rigor.** In this study, *commitment* was demonstrated by a high degree of attentiveness being paid to the participants during the interview process and the care taken during the data analysis process. Making the participant comfortable and paying close attention to what they are saying was a high priority. In turn, analyzing the data required carefully transcribing the data collected and then reading and re-reading the transcripts to extract the true meanings of each participant. During the analysis process, the researcher ensured that there was an idiographic focus and that interpretation was beyond just a simple description ensuring that sufficient *rigor* in the analysis was present. Good IPA studies not only tell the reader something important about each individual, but also tell the reader something important about the themes they share, supported by quotes that individual participants make (Smith, Flowers, & Larkin, 2009).

**Transparency and coherence.** *Transparency and coherence* are present in this final report as demonstrated by paying close attention to making a coherent argument based on the findings. Adequately describing the research process and then adhering to it, as well as careful
writing and re-writing of the final report, is evidence that the researcher was transparent and coherent in his approach. In addition, the researcher asked participants to review the transcripts of their interviews to ensure that the data collected and transcribed clearly reflects the participant’s perspectives of their participation in the SI sessions. Finally, the use of actual participant quotes to support the themes and patterns further ensures transparency and coherence. Evidence of these characteristics are present within the write-up, which demonstrates to the reader that the research is complete and valid (Smith, Flowers, and Larkin, 2009).

**Impact and importance.** Simply put, when the research is well planned, executed with care and, when complete, shares with the reader something important and useful, it adds to the validity and credibility of the study. Since most of the current research on SI focuses on the quantitative benefits to students, for example, improved grades, higher GPAs and higher graduation rates, this study provides important qualitative data on the student’s perspectives of SI and how they make sense of their experiences in participating in SI sessions. The findings help those interested in SI to start to understand the student’s perspectives and sense-making of their SI experience, so that more effective SI programs can be implemented.

**Limitations**

A limitation of this study was the researcher’s association with Tech College and the resulting potential for researcher bias. Specifically, the researcher has been a faculty member and administrator at Tech College for over fifteen years and was familiar with the academic program, the faculty member, and the SI Leader involved in the study. The threat to validity and credibility was, therefore, a consideration during interview discussions. Care was taken by the researcher to keep his position at the college unknown to participants and to avoid influencing participant input based on his knowledge of the program. As mentioned above, to improve the validity and
credibility of this study, participants reviewed the transcripts from each of their interviews in order to validate the transcription and interpretation of the data collected.

Notwithstanding the above, the familiarity with the institution led to a more casual, trusting and rich dialogue between the researcher and the participants. This familiarity also enabled a more accurate understanding of issues and concepts discussed, since the researcher was familiar with the culture of the college and the terminology used when discussing the program.
Chapter 4: Findings and Analysis

This study was designed to investigate how engineering technology students, taking a math intensive course, make sense of a supplemental instruction program designed to help them to connect math concepts to engineering technology applications. Data analysis identified three super-ordinate themes and six related subthemes. The super-ordinate themes (bolded) and their related subthemes (italicized) are: Developing confidence in applying math concepts with subthemes of Problem setup, Real life examples, and Developing confidence; Desiring structure with subthemes of Review previous topic(s), Introduce new topic(s), and Well prepared SI Leader; and Wanting more time. In table 1 below the super-ordinate themes and related subthemes are listed, as well as the rate of occurrence across participants.
Table 1

Superordinate and Subthemes with Rate of Occurrence Across Participants

<table>
<thead>
<tr>
<th>Super-Ordinate Themes Subthemes</th>
<th>Steve</th>
<th>Pete</th>
<th>Joe</th>
<th>James</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing confidence in applying math concepts</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Problem setup</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Real life examples</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Developing confidence</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Desiring structure</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Review previous topic(s)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Introduce new topic(s)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Well prepared SI Leader</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Wanting more time</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

The remainder of chapter 4 will provide a detailed discussion and analysis of the superordinate themes and their related subthemes. Quotes from participants will be used to ensure that a rich narrative, that is comprehensive, systematic and persuasive, is presented to the reader.

Developing confidence in applying math concepts

Math intensive courses in engineering technology can pose challenges to students who struggle with connecting important math concepts to the solution of complex engineering problems. The first super-ordinate theme, identified in this study, was the development of confidence in the application of math concepts in solving engineering problems, as perceived by the participants of the SI sessions. Application of math concepts, as referred to in this study, relates first to the participants understanding of what math concepts are needed to solve the problem and then to how they are applied. Students struggle with selecting the appropriate math formulas needed to solve an engineering problem. They tend to select a formula without first carefully considering what information was given to solve the problem and, more importantly,
what specifically they are being asked to solve. However, as students become more and more successful in solving complex problems, they become more confident in applying the appropriate math concepts. The researcher identified three specific subthemes related to the super-ordinate theme *Developing confidence in applying math concepts*.

First, the participants identified the need to setup the problem correctly before applying math to solve the problem. Setting up the problem includes writing down all the information that was given to solve the problem and, if appropriate, drawing a diagram to visualize the problem. This allows students to visualize the problem and to carefully consider the math concepts needed to solve the problem. Next, the participants viewed the use of real life examples as important in their developing a detailed understanding of applying math concepts to solve complex engineering problems. In this case, real life problems refers to the use of examples specifically linked to the engineering technology course for which the students are enrolled. Since students are motivated by topics that are of interested to them, using real life examples makes the solving of the problem more the focus, and the math just the tool used to solve the problem. Finally, the participants identified that they had gained confidence by participating in the SI sessions, over the course of the academic term. The confidence came in three forms; confidence in their ability to solve complex engineering problems, confidence that they were better prepared to receive and retain new material, and confidence that they gained by teaching their classmates during small group work. Confidences that they believe will carry over into subsequent engineering technology courses.

**Problem setup.** Understanding how to solve a complex engineering problem requires that you first understand what information is given to solve the problem and second what math concepts to select to solve the problem based on what is given. In addition, drawing a diagram
may be appropriate so that you can visualize the problem thus reinforcing the selection of the appropriate math concepts before trying to solve the problem. Two of the four participants felt very strongly that the biggest take away from the SI sessions was the importance of setting up the problems assigned before trying to apply math concepts to solve them. They realized that before starting the solution to a problem, they needed to write down all the data that was given and then needed to draw a diagram, if necessary, so that they could visualize the problem. This step was necessary for them to think through the data that was given and to understand what the problem was asking for.

James emphasized the importance of setting up the problem when he stated “Setup is so key for me, and the way she (SI Leader) runs her SI sessions, that's what we do. We set the problem up, and then we solve it. We set another one up and we solve it.” Similarly, Joe identified the importance of the SI Leader demonstrating the problem setup when he said,

I liked how she kind of drew the picture out rather than just jumping into the math. Once you do that, it kind of makes the math a lot easier for you. You got to know that you fully understand what's going on and you're not just winging it.

These participants indicate here the importance of the SI Leader demonstrating the setup of the problem before solving it, with Joe expressing the confidence that he perceives from properly setting up the problem when he says “once you do that, it kind of makes the math a lot easier for you.”

Since the SI sessions were structured utilizing this approach to problem solving, through the behaviors being demonstrated by the SI Leader, the participants eventually understood the importance of setup before solving complex engineering problems. As a result, they seem to have retained this important behavior.
In further probing participants regarding their biggest take away from participating in the SI sessions, James stated:

Personally, for me, I feel that it's definitely the setup. The math, I'll make some sign errors here and there, but I'm confident with my math, with my trig, and algebra and geometry and all that, but it's the setup. Once I've got the setup down, I can muscle through all the algebra and all that grunt work.

He continues to say:

One thing I always do now ... I'll draw a free body diagram for the problem, that way it just makes much more sense to me as opposed to just trying to grab things from the problem and throwing numbers all over the place. That's just always my first step. It's just reassuring to me that I'm taking the right approach initially by drawing that free body diagram. It's trained me to setup the problem, so I can pull things out what I know I need.

Here James is stressing the importance of problem setup as “reassuring” him that he is “taking the right approach”, a sign of confidence that he is solving the problem correctly.

Similarly, Joe emphasizes the importance of the problem setup and considering the information that was given before trying to solve the problem when he expressed:

The high level engineering kind of thinking goes into setting up the problem correctly, understanding what you're given and understanding what they're asking you to find.

Then it's picking the formula and plugging in the numbers and coming up with a number.

James’ and Joe’s statements illustrate the importance that they put on understanding and setting up the problem before applying any math concepts in solving the problem, resulting in confidence that they are applying the appropriate math concepts to solve the problem. James goes on to say “…understanding what they're giving me, what it means, are all the units correct
so that I can manipulate everything to get an answer that makes sense.” Both participants demonstrate a deep understanding of the importance of problem setup before problem solving. This is a direct result of the SI Leader demonstrating this behavior during the SI sessions and in turn resulted in the participants making sense of the importance of this behavior. Joe confirms this when he says, “You got to know that you fully understand what's going on and you're not just winging it.”

The participants in this study did not understand the importance of setting up a complex problem before trying to solve it. This lack of understanding limited their ability to select the appropriate math concepts to solve the problem, resulting in a marginal problem solving process that relied on the selection of math concepts based on a more limited understanding of the problem. Further, the use of a diagram to visualize the problem strengthened their understanding of what was being asked for, resulting in a more informed decision regarding the selection of the appropriate math concepts. This new behavior results in the participants having more confidence in solving complex engineering problems.

**Real life examples.** Since students struggle with connecting the use of math concepts to solving engineering problems, using real life examples helps to focus the participants more on solving the problem, that is of interest to them, and the math concepts simply become the tools needed to solve the problem. Three of four participants agreed that using real life problems, related directly to the course that they were enrolled in, made the application of math concepts more relevant. Prior to participating in the SI sessions, the participants had difficulty in connecting important math concepts to solving complex engineering problems that resulted in them asking their math professors “Why do I need to know math?”. Steve commented that in the SI sessions he liked the fact that,
We'd get a real example out of it. Last week we went over torsional stress. She (SI Leader) brought in Play-Dough to kind of demonstrate how torsional stress works, then we were assigned a problem to solve. It was easier to solve with the visual understanding that we got from the Play-Dough demonstration.

This comment indicates that Steve places importance on making the application of math concepts relevant, by using real-life problems and visual aids to demonstrate complex engineering topics.

Joe made sense of the importance of using real-life examples, stating that when reviewing a problem either in the SI session or the course itself that

What was also nice, the SI Leader and the Professor, they both had a way of relating it to the real life and where you would use it and how you would use it.

Joe made this comment after stating that the mechanical engineering technology program was very math intensive and explained that the more problems that you solve the better you become at the application of math, especially when you can connect the math to solving problems that are relevant to what you are learning. In Joe’s prior learning experiences he felt that math was a separate subject from his engineering technology courses indicating that he did not see a strong connection between the two subjects. Joe went on to express that he and some of his classmates wished they had SI sessions for past classes, stating,

It (SI session) was definitely very, very helpful. I know everyone I've talked to about it was very pleased with it. Like I said, a few of them even said that, ‘I wish we had it for kinematics because that class became pretty tough towards the end.

Joe is making a connection here that the SI sessions make complex, math intensive courses more manageable for students, giving them more time to understand the topics and providing them a
second source (the SI Leader) for acquiring important concepts and in-turn retaining them.

James also felt that it was beneficial to use real-life examples. When asked to share his thoughts regarding the use of real-life problems and if he thought it helped to better understand the material being studied, he stated:

Yeah. I'd say it has. I could make that connection. I can visually see how an object, let’s take us learning how to locate the centroid of an object. Now I can see using the math how it would directly apply to that particular object's shape whereas before I might have had a little difficulty if you showed me a triangle that was just a bit oblique in some fashion, I may have had a difficult time pointing out the center of it whereas now I can use that math to identify the proper center location of that shape. That's just an example of math being applied.

James, like Steve, places importance on the visual aspects of using real-life examples. It’s apparent that when a student can visualize the problem, it becomes easier for them to select and apply the appropriate math concepts to successfully solve the problem. When asked if he felt more comfortable with applying math to real-life problems, he replied, “Yeah. In that regard absolutely. Using it for real life scenarios. Definitely.”

As demonstrated by the participant’s comments above, making the application of math concepts relevant by using real-life problems is clearly important to them and as a result gives them confidence that they are solving the problem correctly. In addition, providing visual aids and demonstrating the engineering concept helped students to select and apply the appropriate math concepts.

**Developing Confidence.** The participants did express, in various ways, that they did develop increased confidence by participating in the SI sessions. Three of the four participants
agreed that they increased their confidence in solving complex engineering problems and in their understanding of the topics being discussed in the course, as a result of participating in the SI sessions. James commented that, “I feel more confident with my math, with my trig, especially applying it to solve problems.” When asked to describe specifically what makes him feel more confident, he replied,

It's just reassuring to me that I'm taking the right approach initially by drawing that free body diagram. It's trained me to setup the problem, so I can pull things out that I know I need.

Here James links visual aids as important during the problem setup to reinforce for him that he is “taking the right approach” which as a result gives him confidence that he is solving the problem correctly. James goes on to say,

Pick a class that has to do with math, and I feel that this SI session will be helpful to me anyway because I feel that's how I learn the best. They're like push-ups for the brain, so to speak. The more you do, the stronger you'll get.

James’ reference to getting “stronger” indicates that he feels more confident as a result of the additional problems that he was assigned during the SI sessions. Further, “push-ups for the brain” suggests that James has come to the realization that practice makes perfect when it comes to using math to solve complex problems, another indication that he is more confident.

In addition, when Steve was asked to describe his math ability, after attending the SI sessions, and his ability to apply these skills to solve engineering technology problems, he said, “I would say more confident, especially with a few things that we mentioned, like understanding the units and things like that.” Then, Steve added, “I definitely felt confident about what was going on in class, especially having an hour to sit and brainstorm (in the SI session)” with the SI
Leader and his fellow classmates about the new material that would be introduced in class that night. He continues,

One of the advantages to having the SI session was it broke it up a little bit. You get instruction from (the SI Leader). She goes over things a little bit differently than (Professor) would and vice versa. That was kind of a nice change.

Steve perceives another form of confidence gained in the SI sessions, specifically being the confidence that he is more prepared for the new material. Although not stated specifically, this should result in Steve participating, at a higher level, during the faculty’s presentation of new material.

Finally, when asked to explain the important experiences that he had during the SI sessions, Joe commented, “For me, when I show somebody how to do something that I've learned, it's just making me better at what I'm showing them.” This indicates that Joe perceives a gain in confidence in terms of his mastery of complex engineering topics because he able to explained these topics to his fellow classmates. When asked if there were other important experiences that he had during the SI sessions, Joe states,

Hearing the introduction of something new from her (the SI Leader), you kind of pick up on small pieces of it and then when (the Professor) went over it in class, you kind of had an idea of where to start. From there you could kind of like learn some more from (the Professor) and her way of teaching and then just kind of put it all together. With math, there's never one way to figure anything out, so it's helpful seeing different ways.

Similar to James’ comment above regarding feeling “stronger”, Joe makes sense of his SI experience indicating the importance he places on “seeing different ways” of solving complex problems. Seeing the SI Leader and the professor solving problems using different approaches
gives Joe confidence that he understands the material.

Finally, in a comment regarding the importance of setting up the problem before solving it, Joe states,

I liked how she (the SI Leader) kind of drew the picture out rather than just jumping into the math. Once you do that it kind of makes the math a lot easier for you. You got to know that you fully understand what's going on and you're not just winging it.

This indicates that Joe has developed more confidence in solving complex engineering problems by understanding the importance of setting up the problem, drawing a “picture” and fully understanding what the problem is asking you to do before attempting to solve the problem.

There were three ways that participants perceive that they have become more confident by participating in the SI sessions. First, by understanding the importance of program setup and the use of visual aids gave participants confidence that they were selecting and applying the appropriate math concepts to solve the problem. Second, participants felt more prepared to receive new material as a result of participating in the SI sessions, seeing the information presented by two different sources resulted in them being more confident that they were ready to receive, understand and retain the new materials being presented. Finally, as a result of working in small groups during the SI sessions, participants gained confidence after teaching their fellow students engineering and math concepts that they had mastered.

From the participant’s perspective, problem setup, use of real-life examples and developing confidence were important findings in this study. Prior to participating in the SI sessions, participants did not fully understand the importance of problem setup, drawing diagrams to visualize the problem and only then selecting the appropriate math concepts to use to solve the problem. Further, using real-life problems to make the application of the math concepts
relevant was equally important. The use of real-life problems resulted in participants focusing on solving a problem of interest to them, making the math concepts used merely a set of tools used to get to the solution. Now that they understand these concepts, they perceive a gain in confidence in their abilities to apply math to solve complex engineering problems. In addition to feeling more confident in their abilities to apply math to solve complex engineering problems, the participants also expressed an increased confidence in coming to class each week prepared to learn the new topics being introduced. New topics being introduced by two different sources, the SI Leader and the faculty member, gave participants an additional opportunity to “see” new materials delivered in different ways. This resulted in participants feeling more confident that they understood the new material. Finally, the participants also perceived a gain in confidence when given the opportunity, in small group sessions, to teach their classmates the topics that they had mastered. They enjoyed the opportunity to share the knowledge that they acquired with their classmates.

**Desiring structure**

Successful SI programs need to be well coordinated between the SI Leader and the faculty member who is teaching the at-risk course. The second super-ordinate theme in this study documents the importance, from the participants’ perspective, of a structured approach to each SI session. The participants expressed the value they assign to knowing how the SI sessions would be organized so that they could anticipate what was going to happen each week in these sessions. The participants valued the fact that they would briefly review the previous week’s topics before moving on to the present week’s topics. This provided them a sense of security knowing that they had another chance to ensure more complete knowledge of past topics before moving on to new topics. Reviewing key concepts before moving on to new topics required close coordination
between the faculty member and the SI Leader, ensuring that the SI Leader was well prepared for each SI session. The three subthemes that capture the convergence of all participants thoughts on the importance of structured SI sessions were: *Review previous topic(s)*, *Introduce new topic(s)*, and *Well-prepared SI Leader*.

**Review previous topic(s).** All participants expressed, in their own way, the importance of reviewing the previous week’s topics before moving on to new topics. James’ first response, when asked to describe the SI sessions was,

> It's been pretty great. In general, it's a great way to review the subjects, the material that we've learned in the prior weeks, and it's also a great way to gear up for the upcoming lessons. It's just a great refresher from last week, and a good introduction for the upcoming lesson.

This statement demonstrates that, from James’ perspective, having structure so that students can anticipate what to expect during the SI session is important. This of course requires close coordination between the SI Leader and the faculty member so that the SI Leader knows specifically what is being covered in course from week to week. In order to ensure that this was accomplished, the SI Leader participated, with students, in the course itself. She attended all of the lectures as a student, therefore experiencing firsthand what the students experienced. Later in the interview when asked to define the key benefits of the SI sessions, James again described the importance of reviewing the previous week’s topics stating, “As I said earlier, it's a great way to review the subjects from the previous week.” James makes sense of his SI experience by specifying the importance he places on reviewing the previous week’s material before proceeding to any new material.

Since this was an evening course and only met one night a week, Joe made sense of the
SI sessions, when he said,

    It was just very helpful because only having the class once a week, you get like a little bit of a review before you get back into class again for the next thing. It was definitely helpful for that.

In addition, when Joe was asked to describe how the SI sessions would start, he explained:

    Pretty much we'd start off with, like I said, a review and then you know, if we had time, we would try something else. Everyone always had different questions, wasn't understanding some portion of it (the previous topic), so we actually ran out of time a lot.

    This was the only bad thing (running out of time).

Since Joe and many of his classmates work full time jobs and attend school in the evening, having these structured SI sessions seem to provide them a comfort level that they will have a chance to review the topics from the previous week, with a knowledgeable SI Leader, prior to being introduced to new material.

    Similarly, when discussing the weekly structure of the SI sessions, Pete shared, “she (the SI Leader) spent some time on the previous week's assignments to make sure you got it and then moved on to this week’s assignments.” As the interview progressed and Pete was asked if the SI sessions changed over time with regard to the amount of time spent on review of the previous week’s material, he stated that towards the end of the term,

    I want to say maybe, depending on the subject, I feel that 25% of the time was spent on past material, just real quick to remind you, and 75% of the time was spent on what's going to be ahead.

This scenario indicates that the structure of “review then introduce” changed over time in terms of the amount of time spent reviewing previous material versus introducing new material. This
suggests that, over the course of the term, participants benefitted more from the introduction of new material. As a result, they wanted to spend more time on this, so came to class more prepared with regards to the previous week’s material.

Finally, Steve expressed it this way,

Yeah it made such a difference, especially having a few minutes before class started to get in the mindset, especially the way (the SI Leader) ran those sessions and reviewed the material from the week before.

The phrase “to get in the mindset” indicates that Steve appreciated that the SI sessions provided him time to forget about work and to get focused on his studies, at the same time he made sense of the importance that he placed on the opportunity to review the previous week’s material.

The importance participants placed on starting the SI sessions with a review of the previous week’s topics was evident in the comments of all the participants. This structure provided participants with a comfort level of knowing what to expect and giving them one more opportunity to review the previous week’s material before moving on to new material. As time progressed, one participant explained that the “review” time decreased and the “introduce” time increased. This seems to indicate that the students valued the time spent on new topics more than the review of previous week’s topics as the term progressed. This could be a result of students developing new behaviors and motivations in terms of being more efficient in retaining the previous week’s materials or that they started to spend more time out-of-class reviewing the previous week’s material, so that they would have more time during the SI sessions to focus on the new material.

**Introduce new topic(s).** While the participants expressed the importance of reviewing the previous week’s topics before moving on to new topics, they equally expressed the
importance of introducing the new topics to be discussed in class following the SI session. In discussing the structure of the SI sessions with Steve, he stated,

> It was kind of like the last five or ten minutes of the SI session we'd go over what we're going to do and kind of have an idea (of the new topics), and I thought this was really a good way to go about it. She (the SI Leader) would ask a fundamental question and started getting us to think conceptually, what's going on with this?

Then when asked about how much time was spent on the introduction of new material as the SI sessions progressed, he said,

> I definitely felt confident about what was going on in class, especially having had an hour to sit and brainstorm. Towards the end of the quarter, most of the time (spent in the SI session) was definitely spent on forward progression and new material.

Later, as Steve continued to discuss the benefits of having time in the SI sessions for the introduction of new material, he says “Having that (time for the introduction of new material) ... almost getting your feet wet before you jump in the pool.” Steve uses the metaphor “getting your feet wet” to indicate the value he places on having the opportunity to discuss the new material “before you jump in the pool” or before attending the actual class where the new material will be introduced formally. Steve perceives that the time spent on the introduction of new material is important in preparing him for the class that follows the SI session. As stated earlier, students placed more value on the time spent on the introduction of new material as the term progressed.

> Pete seemed to agree when he stated, “Primarily it (the SI session) became a discussion of the material that was going to be taught in class that night.” As stated earlier, with regards to how the SI sessions were structured as the term progressed, Pete went on to say,

> I want to say maybe, depending on the subject, I feel that 25% of the time was spent on
past material, just real quick to remind you, and 75% of the time was spent on what's going to be ahead.

Again, this is an indication that the participants put more value on the introduction of new material as they participated in more SI sessions and potentially indicates that participants spent more time out-of-class mastering the previous week’s material so that they had more time for the new material.

Furthermore, Joe had different thoughts when describing the importance of introducing new material during the SI session. From his perspective,

Hearing the introduction of something new from her (the SI Leader), you kind of pick up on small pieces of it and then when (the Professor) went over it in class, you kind of had an idea of where to start. From there you could kind of like learn some more from (the Professor) and her way of teaching and then just kind of put it all together. With math, there's never one way to figure anything out, so it's helpful seeing different ways.

This is an important concept in that participants have different learning styles and being exposed to the SI Leader, before class, and the professor, in class, provides the students the opportunity to see and hear the introduction of the new material from two sources. As Joe described above, it's helpful seeing the same material presented in “different ways.”

James had yet another view of why the SI sessions were important in terms of introducing new topics and getting students prepared for class when he states,

I just feel the way I learn is practice makes perfect, so if you're doing these problems before class, and you're preparing yourself for the upcoming class by doing more problems, I just feel that will always help you with math.

James’ comment illustrates the importance that participants put on the assignment of and access
to enough problems to solve, so that they have the opportunity to repeat important math processes applied to different problems. He perceived that this not only helped him to strengthen his math capability, but it also prepared him for the upcoming class. Repeating exposure to the complex processes used to solve engineering problems will create lasting and retrievable images that students will use in subsequent problem solving activities. Like the other participants, James also placed importance on the introduction of new materials, during the SI sessions, when he said, “it's also a great way to gear up for the upcoming lessons.”

All of the participants expressed, in their own ways, the importance of using some of the time in the SI sessions for the introduction of new material that would be discussed in class that week. Whether the importance was getting students “thinking conceptually” about the new material, or hearing the material introduced by two different sources, or just preparing participants by solving multiple math problems to get mathematically ready, it was important to these participants to spend time introducing the new material just prior to the start of the actual class. In addition, it was apparent that participants valued the time spent on the introduction of new material as evidenced by more time being allocated to the introduction of new material as the term progressed.

**Well prepared SI Leader.** The final subtheme within the super-ordinate theme of *Desiring Structure* relates to the importance of a well prepared SI Leader. The SI Leader in this case was a professional tutor who works in the college’s academic tutoring center and who graduated from the same engineering technology program for which these SI sessions were being offered. As a result, she was qualified to teach and was enthusiastic about the topics being taught in the course. The participants appreciated this and as James expressed,

She's got a good energy about her. You could tell she's excited about the material. There
aren't too many delays or pauses when she's speaking. You can tell she thoroughly understands the material, so you know you're getting a quality answer and a quality explanation from her. She just has a certain enthusiasm about her which is helpful. It's contagious for the class.

James’ comment expresses the importance of an SI Leader who is not only well prepared from the point of view of knowing the material, but who is also enthusiastic about the topic. James felt that the enthusiasm was “contagious” indicating that he was motivated by that. James went on to say,

She was great. She was really great. I like the way she explains the materials. You could tell she's obviously qualified... Now that I know she's got her masters in math. Even before I knew that, you can just tell she knows what she's talking about. She has a certain way to convey that. She just never seems to stumble up. There's never any stutter in her speech. It's pretty impressive because it's easy to stutter and stumble up when you're talking about those types of things. It's nice knowing that she has a solid background.

Similarly, Joe expressed another view, and a key characteristic of a well-structured SI session, when he said,

She was very helpful. Even after the SI session ended, she stayed in our class. She kind of sat in the back and I did also. If I was talking with my friends and asking them a question on what to do and she heard it, she would turn around and still help me even in the middle of the class. It wasn't just like the SI session she was helping with, she was helping with the whole class. She was really good at it, too. Like I said before, hearing it once from somebody it might not click but then you hear it from somebody else, put in different words, it might make more sense.
Having the SI Leader not only conduct the SI sessions, but to also participate in the actual class makes a big difference for the participants. Not only does it better prepare the SI Leader, since she is experiencing the same lectures as the participants, but it gives the participants more confidence that the SI Leader is prepared and that her instruction is just as valuable as that of the faculty member. This approach also positions the SI Leader as a mentor since she is experiencing the same lectures as the participants while at the same time she is perceived, by the students, as an expert in the subject. As a result, the relationship that she forms with the students makes them more comfortable making mistakes during SI sessions because she is not a faculty member (authoritative), but is a mentor.

Steve expressed the importance of having a well prepared SI Leader in a similar way to Joe, when he stated,

One of the advantages to having the SI session was it broke it up a little bit. You get instruction from (the SI Leader). She goes over things a little bit differently than (the professor) would and vice versa. That was kind of a nice change. Especially not just in the SI session, but leading into class, almost having two instructors in the class.

In order to be well prepared, the SI Leader must coordinate closely with the faculty member to ensure that, each week, the SI Leader is covering the same material as the faculty member. In part, this is evident to the participants because the SI Leader attended the classes each week after the SI session. This allowed her to hear the professor delivering the new material first hand with the participants, therefore making it easier for her to make the SI sessions more relevant to the participant’s specific needs. The participants made sense of this as a benefit because it exposures them to two different teaching styles which, for them, enhances the learning environment.

In addition to the SI Leader being well prepared and qualified to facilitate the SI sessions,
it was important to the participants that she was also well prepared in terms of the materials used during the sessions. Pete shared, that each week she provided

    Handouts with basically worksheets with problems laid out to work through or there were already problems written up on the board for us to solve.

He goes on to discuss how the problems would be organized, since many of the concepts from the previous week would be used as a foundation to add the present week’s concepts. He states,

    Sometimes it would be, like I said, a problem related to last week’s material, just to touch up on real quick. But the main thing was problems related to the new material, if last week's material builds on what we're learning this week, then the problems would require last week’s knowledge.

This statement demonstrates the value that the participants put on the structure of the SI sessions and the preparedness of the SI Leader and her ability to assign problems that will appropriately scaffold the knowledge needed by students to progress to new topics.

    To further stress the importance having a knowledgeable and well prepared SI Leader, James added a similar perspective when he said,

        Her main job would be to answer any questions we have about the material and more specifically to help us understand how to work through the problem. Just saying that we don't know how to do it, then simply writing the answer on the board, that will never happen. She'll walk through it (the solution) step-by-step to ensure that you understand first how to set the problem up, then if it is a math issue ... If it's an algebra or geometry issue, she'll even work through that with you as well. I feel it's expected that I know some of these things such as algebra and all that, but hey, people forget. Everybody makes mistakes, and she'll go through thoroughly how to prevent those mistakes and work
through those algebra problems with you if you have them.

Having a SI Leader that was prepared, qualified and who provided structured SI sessions was very important to these participants. Later, when James was asked what he expected walking into the SI session each week he said,

This Thursday I'm going to expect a worksheet with last week's problem on it. We're going to go through that. Then we're going to have two problems to do (based on new material). We usually get through one of them because they are pretty thorough. If we can touch on the last one, we will, but that's how it's going to go. She'll explain things thoroughly on the board.

The participants identified many perspectives on the importance of a well prepared SI Leader, with the most important being her knowledge of the material and ability to transfer that knowledge. The participants were confident in her knowledge because she had successfully completed the same course in the past and she participated with them in the actual course taught by the faculty member. She participated in the course as a fellow student, developing a peer/mentor relationship with the participants versus a faculty/student relationship. This type of relationship makes the participants feel more comfortable in terms of their interactions with her. Additionally, participants expressed the benefit of “seeing” the material presented by two different people. Exposure to different teaching styles in different learning environments (informal SI sessions versus formal classroom) helped participants to retain more of the material being discussed and to feel more confident when this new material is introduced by the faculty member. Finally, participants discussed the importance of the materials that were used in the SI sessions as being consistent from week to week. This consistency allowed participants to anticipate what to expect in each SI session.
Review of previous topics, introduction of new topics and a well-prepared SI Leader are important to the participants in terms of providing a well-structured SI session. As the SI sessions progressed, the amount of time spent on the review of previous material decreased in favor of the introduction of new material. This perhaps indicates that students started to spend more time out-of-class mastering the previous week’s material so that more time could be spent during the SI sessions on new topics. This may be a result of the confidence and motivation that students received from the feeling of being more prepared for upcoming classes. In addition, students valued the preparedness and enthusiasm of the SI Leader. The fact that she was a graduate of the program and participated in all of the lecture classes with the students, resulted in participants having confidence that she was an expert and that they were receiving quality answers to their questions and instruction during the SI sessions.

Wanting more time

Even though all of the participants were evening students, who work during the day and attend class after work, the participants expressed the desire for the SI sessions to be longer than one hour. The benefits that they received, as discussed above, from the sessions were the driving factor for expressing the desire for longer sessions. As Joe stated,

Everyone always had different questions, wasn't understanding some portion of it (the previous topic), so we actually ran out of time a lot. This was the only bad thing (running out of time). If, you know, some of us could have made it a little earlier we would have had more time, which I know I couldn't have, I was already pushing getting there at four-thirty. I get out of work at four and have a half hour drive.

In further exploring the amount of time allocated for the SI session and asking Joe if he thought that the session should be longer than one hour, he said,
Yeah, sometimes. Definitely you know, like I said, hearing the introduction of something new from her (SI Leader), you kind of pick up on small pieces of it and then when (the Professor) went over it in class, you kind of had an idea of where to start. From there you could kind of like learn some more from (the Professor) and her way of teaching and then just kind of put it all together. With math, there's never one way to figure anything out, so it's helpful seeing different ways.

Again, Joe places value on hearing complex engineering topics delivered by two different sources and indicates that more time in the SI sessions would benefit him and his classmates in this regard. Later in the conversation, when asked about the last few SI sessions and whether the previous week’s topics were reviewed, Joe states,

Yeah, sometimes if we had time, because we only had like an hour before class so trying to get through some of it some weeks it was tough. But then other weeks when we did, she would start to go over like things that were going to happen next, in the class coming up.

While Joe expressed the value he places on having more time to review the previous week’s topics and being instructed on these topics by the SI Leader and then in class by the faculty member. He also expressed that if more time was available that he would have a challenge to get to campus earlier due to work commitments.

Like Joe, James expresses his desire for more time when he says,

We do a lot in an hour. Ideally, we could use more than an hour to get all the problems done, but we're limited on time, so we make the best of it.

This quote represents the conflict that participants have between wanting more time and being able to get to campus earlier if more time was available, therefore the participants “make the best
of it.” Later in the interview, when asked what else he wanted to share with me about the SI sessions, he went back to the topic of more time and offered,

I think it would be great if it went maybe as much as a half hour longer. I don't know if that's too extreme. Fifteen minutes. Just a tad longer. I do enjoy it, and with the worksheets that she gives, we were able to average three problems on the worksheet. We weren't always getting to that final problem done. I believe there were times where we did go back to the problem in the next SI session. It's time constraints. We didn't always do that because you wanted to go over the new material, and that would cut into that time. Maybe just a smidge longer. Not a lot just a smidge.

James advocates that just fifteen to thirty minutes longer would be a benefit in giving the participants time to finish up problems that were assigned when reviewing the previous week’s work and being introduced to the new material.

Pete was promoting even more time and even more SI sessions in a week when he says,

We started to do more targeted towards what lesson was coming up, but sometimes it was review of the homework, which is what I prefer. I wish it was more like ‘come for an hour or even maybe an extra hour for homework and one for say the new material’.

This indicates that Pete was willing to dedicate even more time for the SI sessions, suggesting that he would like multiple sessions to be offered with an hour or two devoted to homework review and an additional hour for the introduction of new material.

When Steve was asked to identify, from his perspective, the key characteristics benefits of the SI sessions, he responded,

Taking an hour before class starts really helps, and if there's time left, obviously just to kind of have a little bit of extra time, to get stuff ready for class.
Here Steve comments that “if there’s time left” indicating that he wanted more time just to get prepared for class. When asked to explain what he means by “stuff”, he goes on to say,

If you're rushing form work and I know a lot of students do. To have that hour just to
kind of get yourself in the ... not the work mode but the study mode and the student
mode.

Steve values the hour not only to complete the SI lessons that are planned, but to also transition from “work mode” to “student mode”. He is expressing the importance that he places on the mental transition from work to school mode and that sometimes the SI session is not long enough to make that transition in addition to completing the planned lesson.

These participants expressed their desire for more time in the SI sessions so that a thorough review of past material and an introduction of new material could be accomplished, with plenty of time to discuss the problems assigned during the session. Their quotes demonstrate their struggle with wanting more time for SI, but needing to work and having a hard time getting to campus earlier. Considering the value that participants put on the introduction of new material, as the SI sessions progressed, it is no surprise that their comments regarding time are mostly focused on having more time to complete the problems assigned. In addition one participant expressed the importance of using some of the SI session time just to transition for work mode to student mode. In closing, the participants perceived the importance of the SI sessions as very helpful in achieving success in this course, but due to the time limitation, in this case an hour, they wished that the sessions were longer in order to have adequate time to complete all assignments.

Summary

This study was designed to investigate how engineering technology students, taking a
math intensive course, make sense of a supplemental instruction program designed to help them to connect math concepts to engineering technology applications. The analysis of the interview data produced several insights as to how the participants made sense of their participation in the SI sessions. The participants learned and placed value on the importance of setting up a complex engineering problem before trying to solve it. This problem setup included writing down all given information and drawing a diagram, if appropriate, so that they could visualize the problem. Only then would they select and apply the appropriate math concepts to solve the problem. In addition, it was importance for the participants to be assigned real-life problems so that there was a relevant connection between the engineering problem being solved and the math concepts required to solve the problem. These types of problems made the use of math relevant which is not always achieved in their math courses. As a result, as the academic term progressed, students developed confidence by participating in the SI sessions. They gained confidence in their ability to apply math concepts to solve complex engineering problems, in their preparedness for class each week and readiness to receive new material, and in their overall knowledge of the material as a result of the opportunities that they had to “teach” the material to their classmates.

The participants also expressed the importance that they put on the structure of the SI sessions. It was important to them to know what to expect each week. They valued a review of the previous week’s material and the instruction of new material provided by a well prepared SI Leader. The participants initially expected more time for review, however as the academic term progressed, that shifted to more time spent on the introduction of new material. This shift from “review” to “introduction” perhaps indicates that students spent more time out-of-class on the previous week’s topics since they were motivated to have more time to spend on the introduction of new topics. The importance the participants placed on well-structured SI sessions could not
have been achieved without a well prepared SI Leader. The participants perceived her preparedness and enthusiasm as the key contributors to the success of the SI sessions. They commented that because she was a graduate of the program and participated in all of the lecture classes with them that they felt confident that the instruction and answers to questions that she provided were complete and accurate.

Finally, participants expressed the desire for more time in the SI sessions so that a thorough review of past material and an introduction of new material could be accomplished, with plenty of time to discuss the problems assigned during the session. They identified conflict between wanting more time for SI and needing to work. It is believed that this contributed to the shift from “review” to “introduction” as the academic term progressed. The participants perceived the importance of the SI sessions as very helpful in achieving success in this course, but expressed concern about the the time limitation, in this case an hour, and the fact that they wished that the sessions were longer in order to have adequate time to complete all assignments.
Chapter 5: Discussion and Implications for Practice

College students face many academic challenges including the application of mathematics to solve real-life problems (DeCorte, 2004; Micari & Light, 2009; Verner, Aroshas, & Berman, 2008; Zinser, 2012). More specifically, many cannot connect math concepts to applications within their academic disciplines. This disconnect can partially be tied to their high school experience (Hoyt & Sorensen, 2001) where instruction becomes segmented and many students become less engaged in the learning process (Malm, Bryngfors, & Mörner, 2012; Wright, Wright, & Lamb, 2002). Their ability to investigate interconnections between what they learn is limited because the teacher has too much material to cover and not enough time (Daggett, 2005). As a result, college students frequently ask why they need to know math, even though most technical disciplines require a solid foundation in algebra or higher (Corbishley & Truxaw, 2010; McCormick & Lucas, 2011). To complicate matters, pass rates in math intensive courses are low (Boughan, 1996). An instructional intervention is required to assist more students in developing their ability to apply math concepts within the courses of their chosen academic discipline (Verner, Aroshas, & Berman, 2008).

The instructional intervention that was investigated in this study is a Supplemental Instruction (SI) math program. SI focuses on “at-risk” courses or courses with a greater than 30% D, F and withdrawal rate (Arendale, 1997) and provides assistance on an outreach basis in regularly scheduled out-of-class study sessions that begin the 1st week of class (Arendale, 1997; Etter, Burmeister & Elder, 2000; Lockie & Van Lanen, 2008). A good SI program should deliver help to students before they find themselves in academic difficulty (Congos & Schoeps, 1993). Many SI researchers have focused on “at-risk” math courses (Burmeister, et al., 1994; Burmeister, Kenney, & Nice, 1996; Fayowski, & MacMillan, 2008; Harding, Engelbrecht, &
Verwey 2012; Phelps & Evans, 2006; Porter, 2010), but only few have focused on math
intensive, discipline specific courses (Etter, Burmeister & Elder, 2000; Jones & Fields, 2001;
Oja, 2012; Parkinson, 2009).

Based on the specific problem of practice as discussed above, the following question was
used to focus the research.

1. How do Tech College students make sense of and attach meaning to the SI program
designed to connect math concepts to their engineering technology course?

Therefore, the purpose of this study was to investigate how Tech College students make
sense of and attach meaning to a SI program designed to help them to make connections between
math concepts and applying these concepts in solving complex engineering problems. This study
employed a qualitative approach called Interpretive Phenomenological Analysis (IPA) that was
designed to capture the participant’s perceptions of the phenomenon that they have experienced,
in this case the SI session. Since the SI sessions are facilitated by a SI Leader, who is an expert in
the subject matter, and are structured as small group, collaborative learning sessions, Bandura’s
(1977) Social Learning Theory provided an appropriate lens through which to analyze the
participants’ experiences.

Significance of the study

This problem is significant at the College as it is for many other institutions. As
evidenced by Parkinson (2009), historically, in the first year of a biotechnology program,
students have found problems in understanding and problem solving in mathematics (calculus)
and chemistry. As experienced at the College, more and more students taking the Accuplacer
math placement exam are placed into remedial math courses. Placement into a remedial math
course delays students from being able to start their discipline specific classes. In addition, the
College’s experience shows that when students are not taking courses in their chosen discipline, they get frustrated and have a higher likelihood of withdrawing. When many students take math intensive, discipline specific courses, they have trouble linking math concepts to applications within their discipline. It is recommended, at a broader level, by Verner, Aroshas, and Berman (2008) that technology applications should be integrated in basic mathematics courses in order to increase students’ motivation, connect mathematics to other disciplines and facilitate the understanding of the mathematical concepts.

For many students, without reliable contexts to anchor meaning, they see math as a meaningless cloud of abstract symbols (Steen, 2007). The success of the SI program, in this study, is demonstrated primarily by the student’s increased confidence in applying math concepts within their chosen discipline. As a result, the hope is that the new behaviors learned by these participants will carry with them not only as they complete their college degree, but also as they enter into the workforce.

**Discussion of Major Findings**

Three super-ordinate themes emerged from the data collection and analysis portion of this research study.

1. Developing Confidence in Applying Math Concepts

2. Desiring Structure


In this chapter, the researcher will discuss each of the findings and their relation with the theoretical framework and current literature. Next, the researcher will discuss the implications of these findings in the practical setting, focusing on improving the experiences that students have when participating in SI sessions. Suggestions for improving the structure of SI sessions, based
on the student’s lived experiences while participating in SI sessions, will be provided. Finally, this chapter will conclude with recommendations for future research, including capturing more data regarding the lived experiences of students who participate in SI sessions.

**Developing Confidence in Applying Math Concepts.** Applying the appropriate math concepts to solve complex engineering problems was initially a challenge for the participants in this study. They would try to solve a complex problem by selecting a formula that they thought was needed, before fully understanding the problem and carefully considering what the problem was asking for and what information was given. This demonstrated a dissonance between the math concepts that were needed to solve the problem and being able to successfully solve the problem.

However, after attending the SI sessions that were designed to make the important connections between the math concepts and applying them to solve engineering problems, participants started to develop confidence in their ability to successfully solve these problems using the appropriate math concepts. This confidence was developed over the course of the academic term and manifested itself in three distinct ways. First, through observing the behaviors of the SI Leader, students developed an understanding of the importance of proper problem setup. Bandura (1977) explains that learning is a social process and takes place through the observation of the behaviors of others.

Problem setup consists of understanding the information that is given to solve the problem, being able to draw a picture, when appropriate, to illustrate the problem and only then selecting the applicable math concepts to solve the problem. This behavior, of problem setup before solving the problem, was demonstrated by the SI Leader many times over the course of the academic term allowing participants to see the process repeated consistently and always
yielding a successful solution. Through this repetitive behavior, as demonstrated by the SI Leader, the participants eventually realized the importance of problem setup. This substantiated two of the key concepts of Social Learning Theory that suggest that learning occurs through continuous reciprocal interactions of cognitive, behavioral, and environmental stimuli and that rarely do people learn without seeing the behavior performed by others (Bandura, 1977).

The repetition of solving problems over the course of the academic term, using the same problem-solving process, resulted in the participants understanding and retaining the process, and more importantly being able to recall the process to use in the solution of new engineering problems. This further demonstrates the influence of Social Learning Theory and the four phases (Attentional, Retention, Motor Reproduction, and Motivation) that participants unknowingly go through in order to master the problem solving process. In the Attentional Phase, the effectiveness of the learning is determined by the functional value that the observer perceives from the behaviors that are modeled (Bandura, 1977). By the SI Leader using a consistent process for solving complex engineering problems resulting in the successful solution of the problem, participants realized the functional value of using the process. However, realizing the functional value alone does not result in participants successfully solving future problems.

Student learning will not be influenced by observational learning if they do not remember it (Bandura, 1977). Therefore, in order for participants to be able to use this new behavior to solve future problems, they first have to retain it. This was accomplished through the repetition of the same problem solving process over the course of the academic term. The repetition of the problem solving process was instrumental in making the process a habit, resulting in participants creating and storing enduring, retrievable images that can be recalled to solve future problems.

Being able to repeatedly and consistently perform the newly acquired problem solving
behavior requires the participant to recall the stored images of the behavior and then to apply it to solving the new problem. Bandura (1977) refers to this as the Motor Reproduction phase. This is the phase when participants have mastered the new behavior and therefore become more confident in their problem solving skills. This ability to apply the newly acquired problem solving behavior, resulted in a significant increase in their confidence. Of course the acquisition of this new behavior happened at different times for each participant and their ability to effectively use the new behavior was adjusted and improved as the academic term progressed, resulting in more and more confidence as they successfully solved more and more problems.

The successful use of the new behavior and increased confidence that resulted was motivation for the participants to continue to use the behavior. This confirms Bandura’s (1977) suggestion that most people are more likely to adopt modeled behaviors that result in outcomes that they value rather than those that have negative effects. The participants in this study truly valued the importance of problem setup, as demonstrated repeatedly by the SI Leader, because the process always resulted in the successful solution of the engineering problem presented.

In addition to demonstrating successful behaviors to students, resulting in increased confidence as they mastered the new behaviors, the SI Leader, acting as a mentor to the students, also developed each student’s ability to become more academically independent. The student’s future performance in applying math concepts within the context of their discipline is a direct reflection of the mentor’s ability to effectively educate the student (Johnson, 2008). The SI Leader’s ability to educate the participants was clearly demonstrated by her ability to instruct students on the importance of problem setup before solving complex engineering problems. This important skill was a key contributing factor in developing the confidence of participants and ultimately resulting in participants becoming more academically independent.
In assisting students in becoming more academically independent, it is important to keep them motivated. The participants in this study were motivated by the use of real-life problems during the SI sessions. The use of real-life problems made the learning during the SI sessions relevant. According to Verner, Aroshas & Berman (2008), the use of real-life applications integrated into the course work, increases students’ motivation, helps them to connect mathematics to their discipline and facilitates their understanding of the application of mathematical concepts. Using real-life examples not only helped the participants to be motivated, but resulted in helping them to develop confidence in their ability to apply the appropriate math concepts in solving complex engineering problems.

Further, the participants expressed the importance that they placed on being able to visualize the problem as a part of comprehending what the problem was asking them to do. Using real-life problems, related directly to the course material being studied, helped the participants to visualize the problem, making it easier for them to select and apply the appropriate math concepts to solve the problem. Without reliable contexts to connect the math concepts to the application, many students only see math as a meaningless cloud of abstract symbols (Steen, 2007). Visualizing problems that are relevant to the participants allowed them to focus more on solving the problem, making the math concepts, needed to solve the problem, simply the tools used to get to the answer.

The use of real-life problems by both the SI Leader, during the SI sessions, and the Professor, during the actual class, provided students the benefit of being exposed to more problems as they develop their problem solving skills. This approach also provided them a second source (the SI Leader) for acquiring important problem solving skills with the ultimate goal of retaining them for future use. According to Bandura (1977), learning occurs through
continuous reciprocal interactions of cognitive, behavioral, and environmental stimuli. The SI sessions, and the use of real-life examples, provided the participants with these continuous interactions in an environment that stimulated them cognitively around the topics in their discipline. In addition, the SI Leader demonstrated successful behaviors that participants valued. Bandura (1977) goes on to explain that rarely do people learn without seeing the behavior performed by others. This is indeed one of the key functions performed by the SI Leader and appreciated by the participants. And, as shared by one participant, there were many occurrences, during the course of the academic term that the participant himself was able to answer questions from his classmates and then teach them the material that he had mastered.

The confidence to teach material that you have mastered to fellow classmates is an excellent example of the benefits that participants received from attending the SI sessions. This benefit was also discussed in a study by McKeachie and Svinicki (2006), where they confirmed that students learn best what they teach. The ability to teach what you have learned not only demonstrates that the participant has acquired a deep understanding of the material, but also demonstrates that the participant has gained the confidence required to teach others this newly acquired material. In addition, it also demonstrates that the participant successfully completed the four phases of Social Learning Theory: Attentional (what the participant extracts as important modeled behaviors), Retention (what the participant retains from the modeled behaviors), Motor Reproduction (ability of the participant to convert the retained behaviors into actions for future learning) and Motivational (how the participant expresses and reproduces the retained behaviors that are self-satisfying to them) (Bandura, 1977). The added benefit to the fellow participants, who were receiving the instruction from their fellow classmate, is the opportunity to see the material delivered by a third source. It's clear that there is no one
instructional method that will reach all learners; therefore, it is up to those designing and
delivering the instruction to offer a variety of approaches (Munro & Rice-Munro, 2004).
Participants teaching fellow participants provides one more opportunity to see and hear the
material being delivered by another source. This helps them to retain important engineering and
mathematical concepts.

In summary, in past math-intensive courses, the participants were not offered the
opportunity to take part in SI sessions designed to help them to connect important math concepts
to solving complex engineering problems. As a result, they were on their own, in terms of
seeking help in making these important connections. Many would seek additional help from
faculty during office hours, would visit the Math Lab in the tutoring center or would work with
fellow students in small study groups. All of these options were helpful in some ways, however
none of these options were designed and structured to specifically make these important
connections. When students compare these past experiences with their experiences participating
in the SI sessions, participants appreciated the SI sessions because they developed new behaviors
that increased their confidence in solving complex engineering problems, and as a result,
increased their motivation to learn. The understanding of the importance of setting up the
problem prior to solving it coupled with the use of real-life problems and a SI Leader that
demonstrated successful problem solving behaviors, resulted in participants with more
confidence in selecting the appropriate math concepts and applying them to solve complex
engineering problems.
**Desiring Structure.** A good SI program should provide help to students before they find themselves having trouble (Congos & Schoeps, 1993) and from the participants’ perspective, the SI sessions need to be very structured and predictable in terms of knowing what to expect each week. The important structural components of a good SI session, as expressed by participants, include a predictable routine from week to week and a well-prepared SI Leader. It is important to the participants that the week to week structure include a review of the previous week’s topics, followed by the introduction of new topics and supplemented by the use of real-life problems that help participants to retain and reinforce their knowledge of the topics being discussed.

In order for the SI Leader to ensure an efficient review of the previous week’s topics and introduction of new topics, a close coordination with the faculty member was required. Burmeister (1996) states that the SI Leader is qualified to lead the SI sessions, as deemed by faculty member, and coordinates with the faculty member to ensure that the SI sessions are aligned with the weekly course content. In fact, the SI Leader in this study participated in the course directly by attending, with the students, all of the weekly class meetings. This is consistent with what Maxwell (as cited in Wright, Wright & Lamb, 2002) advocates when he states that the SI Leader should attend classes, take notes and complete assignments with the enrolled students. Taking this approach, allowed the SI Leader to structure the following week’s session based on the specific needs of the participants as noted during the previous class meeting. In order to accomplish this successfully, the SI Leader was in close collaboration with the faculty member to confirm the areas needing review and emphasis from the previous week’s topics as well as identifying the key topics to be introduced during the next SI session.

Additionally, this allowed the SI Leader to structure the real-life problems given to participants, during the next SI session, to further strengthen their knowledge on the topic areas
that they were having most trouble with. According to participants, this close coordination between the SI Leader and faculty member, in combination with the SI Leader attending the class meetings with participants, resulted in a predictable week to week SI session format. Supplemental Instruction gives students a chance to continue the learning that begins in the classroom and take ample time to struggle with concepts and ideas, work through difficult material, develop effective thinking and processing strategies, and benefit from the synergy of a group working together to solve problems and more effectively engage with difficult material (Hurley, Jacobs, & Gilbert, 2006) before moving on to new material. As a result, participants felt a level of comfort that they would have an additional opportunity to review the previous week’s topics before moving on to new topics.

Not only did this approach provide participants a second chance to review the previous week’s topics before moving on to new topics, but it also provided participants the chance to see important topics delivered by two different teachers. Since participants have different learning styles, whether reviewing the previous week’s topics or introducing new topics, they perceived a major benefit from seeing the same topics delivered by two different teachers. According to Chio and Forde (2002), faculty members need to provide multiple methods to help students master each new subject or problem. Further, these teaching strategies should include formal lectures as well as informal class discussions, individual and group projects, active experimentation such as physical and experiential applied learning, personal feedback and encouragement, and formal structured observations and reflection (Chio & Forde, 2002). The SI Leader did exactly this by providing an important, additional teaching opportunity in the more informal setting of the SI session. Also, the SI session provided an opportunity for participants to apply their knowledge to real-life problems assigned and to receive personal feedback and encouragement from the SI
Leader. As a result, the participants valued the opportunity not only to hear the topics delivered by two different teachers, but also to have the opportunity to ask questions to two different teachers in helping them to clarify their understanding of these topics and to apply their newly acquired knowledge to solve real-life problems.

Interestingly, as the academic term progressed, two participants commented that the amount of time allocated for review of the previous week’s topics decreased in order to leave more time for the introduction of new topics. This suggests that, over the course of the term, participants benefitted more from the introduction of new material. This could be a result of students developing new behaviors and motivations in terms of being more efficient in retaining the previous week’s materials, students spending more time out-of-class reviewing the previous week’s material, so that they would have more time during the SI sessions to focus on the new material, or it could be a direct reflection of the SI Leader’s ability to effectively tutor students, which Johnson (2008) confirms is very important.

Providing a predictable structure for the SI sessions was important to the participants. According to Hurley, Jacobs and Gilbert (2006), each session should begin by setting the agenda, go on to provide group work that employs one or two learning strategies, and finally provide a closing activity. Knowing that they would have a second chance to see and review the previous week’s topics coupled with the chance to see these topics delivered by a second source (the SI Leader) provided participants with a level of security that they had more opportunity to develop a deeper understanding of these topics before moving on to new topics. Since most topics in this course require knowledge from previous weeks, in order to successfully progress, having time in the SI session to revisit topics not yet mastered, with access to an expert who can provided clarifications, was a major benefit as perceived by the participants. The SI Leader assigned
problems that appropriately supported the attainment of the knowledge needed for participants to advance to new topics successfully. The SI Leader thus needs to structure the SI session plan so that students engage with the material in the way that the professor wants them to (Hurley, Jacobs, & Gilbert, 2006). An SI Leader that has a deep understanding of the topics to be covered, with the ability to transfer that knowledge, is key to the success of a good SI program. In addition, due to the more informal, yet structured, SI sessions, the SI Leader establishes more of a mentor/peer relationship with participants resulting in students being more comfortable making mistakes, in the presence of the SI Leader, and learning from them as compared to the more formal faculty/student relationship where students may feel embarrassed making mistakes in the presence of the faculty member. Finally, the participants expressed the desire that the material used in the SI sessions should be consistent week to week allowing participants to anticipate what to expect in each session.

**Wanting More Time.** The primary driving factors for wanting more time allocated to the SI sessions were the benefits that participants perceived. The time to review the previous week’s topics, to complete the assigned real-life problems and to introduce and discuss new topics were important to the participants. The participants expressed that in order to accomplish all of this, more time was desired. Also, the participants valued seeing important concepts delivered by two different sources. The opportunity to see the SI Leader reinforce previously delivered content or introduce new, important concepts coupled with the solution of associated problems, to reinforce these concepts, was important to participants, but takes time. Student learning will not be influenced by observational learning if they do not remember it (Bandura, 1977). Having additional time, during the SI sessions, provides the participants more opportunity to observe the successful behaviors as demonstrated by the SI Leader and will result in a higher likelihood that
they will retain those behaviors for future recall. The desire for additional time confirms Maxwell’s suggestion (as cited in Wright, Wright & Lamb, 2002) that SI programs should be designed to provide at least two 50-minute SI sessions per week. As mentioned earlier, the SI sessions offered in this study were offered once per week for one hour.

However, while participants did perceive that they would see more benefit from having more time, they also expressed personal concerns that they would not be able to allocate more time due to work commitments. The researcher reminds you that the participants in this study were adult students who worked during the day and took classes in the evening. Therefore, when selecting the time(s) to offer SI sessions, thought must be given to the population of students being targeted for this type of intervention. Maxwell (as cited in Wright, Wright & Lamb, 2002) also suggests that SI sessions be scheduled at times convenient for most students. Adult Learners attending school in the evenings, while maintaining full-time jobs during the day, have much different personal schedules that full-time, traditional day students.

Next steps

This IPA study documents the participant’s perspectives and sense making after participating in a SI program designed to link math concepts to their application in a math intensive engineering technology course. In the conduct of the study, the participants developed confidence in the application of math concepts in solving real-life problems in their discipline. Notable was the value that participants placed on first setting up the problem before selecting and applying the appropriate math concepts in the solution of the problem. When directly asking participants if offering SI sessions in other courses would be helpful, the answer was universally in the positive. Therefore, an important next step is to work with the College and their administration to facilitate offering additional SI sessions in support of other math intensive
courses. The researcher has already been asked to provide a college wide workshop on the key aspects of offering an efficient SI program discussing the key characteristics of SI and the qualifications of a good SI Leader. This workshop will be given during a Faculty Development Day in which all full time faculty members are present. The goal of the workshop would be to educate the faculty about supplemental instruction, to inform them of the benefits of SI and to share with them the lived experiences of students who participate in SI. With this knowledge, the hope is that faculty will implement SI more broadly across campus to support student success in at-risk courses. Broader implementation of SI would be a valuable addition to the student success support systems already offered by the College.

Communicating the findings of this IPA study more specifically to certain academic departments within the College may also be beneficial. The College offers many more math intensive courses within numerous other academic programs. Students taking these at-risk courses would benefit from the implementation of SI. Sharing more detail with faculty teaching these courses may result in the implementation of more SI programs. The goal of these more focused and detailed presentations, to smaller groups of faculty, would be the acceptance and wider spread implementation of SI.

Recognizing the many benefits of SI programs (i.e., higher grades, better GPAs and the development of confidence in participants) is to become aware of a significant institutional advantage SI offers, potentially making the College’s competitive position in the higher education marketplace stronger. Preserving, protecting and leveraging this advantage has potential relevance to long range planning, financial decision making, new program development, human resource allocation, marketing and admissions. To generate a consistent understanding of what SI is and its value to the College, making detailed presentations on the
findings of this study to various administrative officers and department chairs may be desirable. Through a detailed understanding of SI, the benefits of SI and the student’s experiences in participating in SI, the College can make more informed decisions regarding the broader implementation of SI. Senior administrators at the College are aware of this research study and providing them with copies of this completed study in combination with a presentation of the findings will hopefully result in action to implement SI in support of other courses.

External to the institution, this research has an important narrative to share. The story of the participant’s lived experiences and sense making after participating in a SI program design to help them to connect math concepts to solving complex engineering technology problems adds to the existing literature on SI by providing the student’s perspective. As identified earlier in this paper, there appears to be no published SI research capturing the lived experiences of students who participate in important academic support programs, like SI. Through the publication of this dissertation, this story will be communicated externally, within the higher education community, to share the students’ experiences. In addition, publishing journal articles or making conference presentations (based on this study) at higher education conferences is also a logical next step.

**Conclusion**

The purpose of this practice-based research was to investigate how the participant’s explained and made sense of their lived experiences while participating in a Supplemental Instruction program. The completion of this study resulted in three primary findings. First, the participants developed confidence in their ability to apply math in the solution of complex engineering problems. Secondly, the participants articulated the importance that they place on well-structured SI sessions, so that they can anticipate what to expect each week when attending the SI session. Third, the participants expressed their desire for more time being allocated to the
SI sessions.

With the SI Leader consistently demonstrating successful problem solving techniques and using real-life problems, participants learned the valuable lesson of the importance of setting up the problem before starting the solution. Over the course of the academic term, this resulted in the participants not only acquiring these new successful problem solving skills, but gaining confidence in their ability to apply math concepts to solving these complex problems. Furthermore, it is hopeful that the new behaviors acquired by the participants will carry over to future classes requiring the solution of complex engineering problems. The increased confidence and added value of the SI sessions that the participants expressed indicate that a presentation of the findings of this study to the College faculty would be one way to promote the use of SI in support of more math intensive courses.

This IPA study is also significant to the field of higher education because it reports on the successful utilization of SI programs in supporting student success in an at-risk technical course. Underlying this opinion are the personal testimonies from the participants that demonstrate a consistent belief that SI sessions: help develop confidence, need to be structured, and should be allocated an appropriate amount of time. For colleges seeking to broaden the use of SI programs to support student success, the experiences of the participants in this study may offer an informative perspective.

Finally, this IPA study is but one data source in the scholarly study of supplemental instruction programs in higher education. To generate a true comparative analysis of the students’ lived experiences and sense making as participants in SI programs, many more institutions utilizing SI programs should be researched and reported on. Recommended future studies related to SI programs in higher education include a further understanding of:
• The students’ perspective of participating in SI programs
• The importance of the structure of effective SI programs
• The most appropriate amount of time for the successful implementation of a SI program
References


Dear MCT Student,

My name is Doug Sherman and I am looking for volunteers to take part in a research project as part of my doctoral studies in Northeastern University’s EdD program. You are being contacted by email because you are enrolled in the MCT224 Mechanics of Materials and are eligible to participate in a supplemental instruction (SI) program designed specifically for this course.

The purpose of this research is to explore the student’s experience in participating in a Supplemental Instruction (SI) program designed to link important math concepts to applications in your Mechanics of Materials course. This research is important as there are many studies that have been done that show that student’s grades, GPAs and graduation rates increase when they participate in a SI program, but no studies have explored the actual student learning experience while participating in a SI program. Your participation may help researchers, faculty and higher education administrators to better understand how students view their learning experiences when participating in a SI program.

The research project will involve three face-to-face, audio-taped interviews where you will be asked to describe your past experiences with math (Interview 1), your learning experiences in the SI sessions (Interview 2) and to confirm the accuracy of the transcription of the first 2 interviews (Interview 3). All interviews will be scheduled at a time and place convenient for you. Participation in the study and student identities will be kept completely confidential and will follow Northeastern University IRB and New England Tech HSRB guidelines.

If you would be interested in participating, please let me know by email, no later than Friday, April 4, 2014. I am looking for 4-6 participants and if I receive more than that number, I will let you know whether or not you have been selected to participate as soon as possible.

The consent form that I have attached to this email provides additional information about the study. If you have questions before you decide to participate, please do not hesitate to contact me. If you decide to participate, I will also answer any other questions you may have about the study and will ask you to sign the Informed Consent form and return it to the SI Leader.

Participation in the study is completely voluntary and confidential. You may refuse to join or you may withdraw your consent to be in the study at any time and for any reason, without penalty. You can choose to skip over any question in any of the interviews if you do not want to answer, and can respond as much or as little as you choose to any particular question.

Please email me at sherman.d@husky.neu.edu if you would like to participate. If you have additional questions, you can email me or call me at 401-739-5000 x3481.
Thank you in advance for your consideration in participating in this study.

Doug Sherman
Appendix B

Interview Questions

Research Question
How do NEIT students make sense of and attach meaning to the SI program designed to connect math concepts to their engineering technology course?

1st Interview

1. How would you describe your math ability?
   Possible prompts: past preparation, past experiences?

2. How would you describe your feelings towards math?
   Possible prompts: scared, confident, etc.

3. Can you share your thoughts regarding math and its application to solving real-life problems?
   Possible prompts: How often do you use math? How do you use math in your everyday life?

4. Can you give me an example of how you have used math to solve real-life problems in the past?
   Possible prompts:

5. Tell me about someone in your past that has influenced your feelings about math?
   Possible prompts: teacher, parent, friend?

2nd Interview

6. Can you tell me about your experiences in the SI sessions?
   Possible prompts: what happened? What were the key things that you learned?

7. Can you tell me about the first SI session that you attended?
   Possible prompts: how did you feel? What were you thinking?

8. Can you tell me about the last SI session that you attended?
   Possible prompts: how did you feel? What were you thinking?

9. Can you tell me about the SI Leader?
   Possible prompts: was she helpful? Role model?

10. What was her main job in the SI sessions?
    Possible prompts: teacher, peer, mentor?
11. Can you share your thoughts regarding math and its application to solving real-life problems?  
   *Possible prompts:* How do you use math in the SI sessions?

12. Has your participation in the SI program changed your thoughts regarding math?  
   *Possible prompts:* do you see math differently than before participating? In what ways?

13. How would you describe your math ability and its application to engineering technology problems?  
   *Possible prompts:* more or less confident?

14. Has your participation in the SI program affected your approach in applying math concepts to solve real-life problems?  
   *Possible prompts:* in what ways? Can you give me an example?

15. Were there other skills that you learned as a result of participating in the SI sessions?  
   *Possible prompts:* Can you give me an example?

**3rd Interview**
Review the transcribed interview for accuracy.
Appendix C

NIH IRD Certificate of Completion

Certificate of Completion
The National Institutes of Health (NIH) Office of Extramural Research certifies that Doug Sherman successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 03/14/2010
Certification Number: 413191