THE EFFECT OF SUPPLEMENTAL INSTRUCTION ON CONSECUTIVE-SEMESTER SEQUENCE STEM CLASSES AT COMMUNITY COLLEGES

A dissertation submitted in partial fulfillment of the requirements
For the degree of Doctor of Education in Educational Leadership and Policy Studies

By

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August 2013
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Dedication

I dedicate this dissertation to my family, Elaine, Ian and Corey. They have survived the journey as much as I have.
Acknowledgements

“I can do all things through Him which strengthens me” (Phil 4:13) has been my mantra these past few years. Trying to find one of my alumni on a college website and instead finding that CSUN was offering a doctoral degree was life-shattering and life-creating. From the start of the application process to the last mile of the race, my mantra has kept me sane. Working full-time, taking care of a family, and completing my doctoral study is very much an insane decision, yet people do it all the time. I give credit to those who have come before me and those who will come after me in reaching for a goal that, at times, seems impossible to reach.

I could not have started or maintained this journey without the individuals who believed in me, guided me, and stood by me this whole time. I want to acknowledge Kathy Rodarte who allowed me to start this journey and through her quiet confidence in me, gave me the approving nod each time we met. When Kathy retired and Dr. Scott Thayer took her place as my supervisor, he continued with his own mantra for me. Every time I saw Scott, he said it over and over again. Scott, I still hear that mantra ringing in my ears as write the final words to this dissertation. I want to thank Heba Griffiths who saw me through tears and frustration these past few years, Mahalo my friend!

I also want to thank three people who gave me the room to breathe so that I could get to the finish line, Pablo Carreon, Grace Santiago, and Gaby Rayo. You have helped me see the future and to know that I needed to be there changing students’ lives for the better.

I also need to acknowledge a special group of people from the first CC Cohort who made me laugh, supported my dreams, and encouraged me to continue each day, each semester, and each year. Polly, Tony, Van, Sherry, and my Moorpark friends, Joanna, Lori, and Carol, thank
you from the bottom of my heart. You are precious, loving, absolutely crazy people and I can’t thank God enough for all of us being there when we started this journey a few years ago, and being there when I was ready to complete this journey. I will miss our philosophical discussions, our laughter, and especially our dear friendship for each other.

I need to acknowledge two other people who have helped me develop skills necessary for the completion of this dissertation. I want to thank Nancy Roberts for knowing the perfect word or phrase to make a good sentence into a great one. Thank you for your editorial support and your friendship. We made an incredible team. I also want to thank Dr. Julie Gainsburg for her patience and sometimes her impatience with me. She pushed me to think more deeply and to write with greater clarity and conviction.

Last, I want to thank Elaine, my love, for believing in me when I didn’t believe in me, and for my two sons, Ian and Corey, I love you with all my heart.
TABLE OF CONTENTS

Signature Page ................................................................. ii
Dedication ........................................................................ iii
Acknowledgements .......................................................... iv
List of Tables ..................................................................... ix
List of Figures ..................................................................... x
Abstract ........................................................................... xi

CHAPTER I: STATEMENT OF THE PROBLEM ......................... 1
  Retention and Graduation of STEM Students ..................... 4
    STEM Graduates within Four-Year Colleges .................. 5
    STEM Graduates within Two-Year Colleges ................. 7
  Student Services ........................................................... 9
  Supplemental Instruction ................................................ 12
  Supplemental Instruction and Retention ......................... 15
  The Long-Term Effect of Supplemental Instruction on STEM Students ... 18
  Importance of Study ....................................................... 19
  Definition of Terms ......................................................... 21
  Limitations and Delimitations of Study .......................... 22
  Overview of Dissertation ................................................. 23

CHAPTER II: REVIEW OF THE LITERATURE ....................... 24
  Pre-College Demographic Factors ................................. 25
    High School Curriculum and Grade Point Average .......... 25
    Socio-Economic Status (SES) ....................................... 26
    Parental Education ..................................................... 28
  Persistence within the STEM Major ............................... 29
    General Persistence .................................................... 29
    Relation of College Retention and supplemental Instruction..... 30
  Community College and Developmental Education .......... 33
  Theory Behind Supplemental Instruction ....................... 34
  Supplemental Instruction and its Effectiveness ................ 42
Credit-Bearing STEM and Non-STEM Classes ............................................. 44
Developmental Classes .................................................................................. 46
Impact of Supplemental Instruction and Course Sequence .......................... 49
Summary ................................................................................................................ 52

CHAPTER III: METHODOLOGY ........................................................................... 53
General Research Design ................................................................................. 54
Experimental Design and Validity ........................................................................ 55
Student Population and Sampling ................................................................ 56
Course Sequence ............................................................................................ 60
Variables ........................................................................................................ 61
Data Collection ............................................................................................... 62
Data Analysis .................................................................................................. 63
Institutional Demographics ............................................................................ 65
Correlation ...................................................................................................... 66
Research Question 1A ..................................................................................... 66
Comparison of Means .................................................................................... 66
Independent Samples t-Test ............................................................................ 67
Research Question 1B ..................................................................................... 67
Research Question 2A .................................................................................... 68
Research Question 2B .................................................................................... 68
Research Question 3 ....................................................................................... 69
Validity and Limitations .................................................................................. 69

CHAPTER IV: DATA ANALYSIS ........................................................................... 72
Review of Research Questions .......................................................................... 72
Correlation of Supplemental Instruction and Course Grades ....................... 73
Comparison of Means .................................................................................... 74
Significance of Means .................................................................................... 76
The Significance of Course Grade between Developmental Courses and Going from Developmental to College-Level Coursework .................. 78
Supplemental Instruction Taken in Subsequent Courses ............................... 79
Supplemental Instruction Taken in Two Classes within the Same Semester ..... 84
# List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>63</td>
</tr>
<tr>
<td>4.1</td>
<td>74</td>
</tr>
<tr>
<td>4.2</td>
<td>75</td>
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<td>4.3</td>
<td>77</td>
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<td>79</td>
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<td>82</td>
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<td>4.6</td>
<td>83</td>
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<td>4.7</td>
<td>84</td>
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<td>86</td>
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<tr>
<td>4.10</td>
<td>89</td>
</tr>
<tr>
<td>4.11</td>
<td>90</td>
</tr>
</tbody>
</table>
### List of Figures

<table>
<thead>
<tr>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>60</td>
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<tr>
<td>3.2</td>
<td>62</td>
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<td>75</td>
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<td>4.2</td>
<td>76</td>
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<tr>
<td>4.3</td>
<td>80</td>
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ABSTRACT

THE EFFECT OF SUPPLEMENTAL INSTRUCTION ON CONSECUTIVE-SEMESTER SEQUENCE STEM CLASSES AT COMMUNITY COLLEGES

By

Joy Suzanne Brittain

Doctor of Education Degree
in Educational Leadership and Policy Studies

This ex-post facto study using secondary data assessed the impact of Supplemental Instruction (SI) in consecutive-semester science, technology, engineering, and mathematics (STEM) courses at two community colleges. It also looked at the impact SI had on successful persistence of students. SI engages students through their own learning via social interaction. Prior studies have shown that SI to have greater successful persistence and higher course grades. This study attempted to determine if an additional semester of SI would have an added effect on course grade for both credit-bearing and developmental classes.

Secondary data were collected from two community colleges using a sample size of 6194 students from Community College A and 1534 students from Community College B. Using an independent samples $t$-test, the study found a significant and positive difference between course grades of SI-users and non-SI users with an average of $\frac{1}{2}$ letter grade increase. Using regression analysis, the study found that SI utilized in developmental math did not have an impact on the grade in the subsequent developmental-level math course within the sequence. The study did show an impact that was positive and significant when students utilized SI for consecutive-semester STEM classwork.
SI was shown to have a positive and significant outcome in successful persistence. There was an overall 18.8% increase in successful persistence with developmental coursework and a 25% increase in credit-bearing STEM coursework.

These findings advocate for the use of SI in developmental coursework in contrast to prior studies, which suggested SI was not an appropriate service to use for students in developmental courses. The findings also imply that there is an additive effect of learning, thus SI may be utilized more effectively in a course sequence as opposed to just individual classes. The study suggests that SI is a contributor to the successful persistence of students in community colleges, especially in STEM, an area where there is normally a low completion rate. Finally, the information in this study will aid community colleges in deciding where best to spend their funding for student services.
Chapter I

Statement of the Problem

Science, technology, engineering, and math (STEM) education is the key to continuing America’s sustainability. The United States needs a pipeline of postsecondary STEM graduates. From 1994-2003, the total number of jobs within STEM increased 23% compared to 17% for non-STEM employment, with the greatest increase of 78% within the fields of computer and technology (Government Accountability Office, 2006). Congressional legislation such as the Science and Engineering Equal Opportunities Act of 1980 and the America Competes Reauthorization Act of 2010 have placed STEM education as a priority for the United States. The National Center for Science and Engineering Statistics (NCSES), the research arm of the National Science Foundation, gathers national and international data on the number of students who enter and complete a STEM degree in response to ever-increasing need for STEM graduates. In its 2010 indicators, NCSES states:

The ratio of natural sciences and engineering (NS&E) degrees to the college-age population is one measure of the technical skill level of those entering the workforce. Over time, the United States has fallen from one of the top countries in terms of its ratio of NS&E degrees to the college-age population to near the bottom of the 23 countries for which data are available. (NCES, 2010, p. 2)

Efforts by Congress as well as by business leaders through collaborations with colleges are not only a response to the high need for skilled employees within STEM, but also a response to the U.S. test results on the Program for International Student Assessment (PISA) within math and science. The Organisation for Economic Co-
Operation and Development (OECD) coordinates the PISA Assessment around the world. The results of the 2009 PISA, an assessment of reading, math and science skills among 34 developed countries, ranked the United States 17th in science and 25th in math. The U.S. average fell to the 30th spot when compared to all countries where the PISA was used (Hanushek, Peterson & Woessmann, 2011). The U.S. had an average math score of 487 on the PISA while the OCED countries had an average score of 496, placing the U.S. in the middle of all countries in the study. The PISA also tests proficiency levels of students from Level 1 to Level 6, which is the most advanced proficiency. For example, at Level 4 students are able to answer questions that use higher-level thinking skills such as visual or spatial reasoning. Twenty-three percent of all students tested in the U.S. ranked below Level 2, the baseline for what PISA considers math literacy (U.S. Department of Education, 2011).

The results for science literacy were not much better. Only 29% of students in the U.S. scored at Level 4, which demonstrates that students can do higher order tasks. Eighteen percent scored below Level 2, which means the average science literacy score for the U.S. was similar to the average OECD score. Yet, when compared to all the countries taking the PISA, 18 countries scored higher than the United States (U.S. Department of Education, 2011).

Multiple studies (Norn & Nunez, 2000; Sawyer, 2008; Trusty, 2002) show that the level of course-taking in high school and grades earned within those courses affect one’s ability to do well in STEM in college, but U.S. educators argue that the low scores of American students on the PISA are due to differences in the subject matter being taught throughout the United States versus other countries. They argue that PISA results
cannot compare the United States to other countries since the subjects covered on the PISA do not equate with what is taught to U.S. students. If this is true, and the students being tested have not been taught the material on the PISA Assessment, then using a national assessment looking at the results of only U.S. students would provide the most accurate picture of STEM competency within the United States. The Federal Government conducts a national study of student outcomes through the U.S. Department of Education’s National Assessment of Educational Progress (NAEP). The NAEP compares the results of uniform testing from all states during the 4<sup>th</sup>, 8<sup>th</sup>, and 12<sup>th</sup> grade. The 2009 science test results for 8<sup>th</sup> grade are now available and the scores are dismal. Nationwide, only 30% of all students are considered proficient in science literacy and this percentage decreases to 21% when students are tested for science proficiency in 12<sup>th</sup> grade (U.S. Department of Education, NCES, 2010). The United States is struggling to graduate high school students proficient in math and science (NAEP, 2011).

According to a similar report by the NCES, the 2009 math results also show low proficiency percentages for U.S. students. Only 34% of all math students in the 8<sup>th</sup> grade were considered proficient. By 12<sup>th</sup> grade the percentage of students who were proficient in math decreased to 26%. Test results disaggregated by race/ethnicity and by income level are also available for math and science. The math results (on a scaled score of 0-500) showed that African-American students scored 32 points lower than White students and Hispanic students scored 27 points lower than White students. Those students who were identified as low socio-economic status (SES) based on their eligibility for free and reduced lunch scored 28 points below those not eligible for free and reduced lunch. The results from the science testing are not any better. African-American students scored 36
points lower than Whites and Hispanics scored 30 points lower than Whites. Low-SES students scored 24 points lower than non-low SES students on the science test. As the United States becomes more racially diverse and as barriers of economic disadvantage remain, access to STEM education for those underrepresented in college must increase in order to stay competitive with other countries.

Historically, the U.S. higher education system has stood out as one of the best in the world, particularly in STEM. This is one reason why so many international students who come to the U.S. for their education do so within STEM majors. As of 2007, 4% of undergraduate degree-seeking students from other countries pursue their studies in the United States, but 30% of these same students study in a STEM field. This percentage increases with international graduate students who major in STEM fields. Thirty percent of graduate students in the United States are international students, and of these students, 53% are pursuing a STEM major (National Center for Educational Statistics, 2009). While the international community sees STEM education in the United States as a positive option, only 14% of U.S. students in the 2003-04 cohort year entered college with a STEM major (U.S. Department of Education, NCES, 2009). The America Competes Reauthorization Act of 2010 states that preparing students throughout their whole educational career is a major concern for educational, political and business leaders.

Retention and Graduation of STEM Students

Crisp, Nora and Taggart (2009) suggested that first semester GPA’s will affect whether students are retained or withdraw from a STEM major. Garcia and Hurtado, Gilmer, (2007) Whalen and Shelley II (2010), and White-Brahmia and Etkia (2004) also
showed that college grades affect the persistence rate of students in STEM. For example, Whalen and Shelley II found that there is a twelve-fold increase in STEM retention and graduation for every one-point increment in overall GPA (e.g., 2.0 to 3.0). Having a lower GPA can undermine retention rate of students especially when they do not perform well in pre-requisite and/or gateway courses.

**STEM Graduates within Four-Year Colleges.** The country’s changing demographics cannot be ignored when evaluating the number of STEM graduates in the U.S. In the period from 2001-2004, there was a net increase in the U.S. population of more than 250,000. A great number of these 250,000 new residents were immigrants from Mexico (18%) and India (7%) (U.S. Department of Homeland Security, 2004). This does not count the thousands of families who entered the U.S. illegally and now have children who are college age. One estimate for the years 2007-2009 holds that there are 300,000 people illegally entering the country each year (Passel & Cohn, 2010). Population projections suggest that by the year 2050 the Asian population in the United States will increase by 213% while other non-White populations are expected to jump 217% (U.S. Census Bureau, 2004).

While the minority population in the United States is increasing, the percentage of underrepresented students attaining a STEM degree is still quite small (Huang, Taddese, & Walter, 2000). Riegle-Crumb and King (2010) looked at both gender and ethnic/racial differences in students studying STEM in college. Their study suggested there was no underrepresentation of minority students studying in a STEM major. The same results can be found in the 2010 Science and Engineering Indicators (National Science Foundation, 2010) and in research completed by Anderson and Kim (2006). In fact,
Hispanics entered college with a STEM major at a higher rate than Whites (22.7% v. 18.0%).

Yet, there is a difference between studying STEM and graduating with a STEM major. Anderson and Kim (2006) saw that African-Americans and Hispanics do not persist in a STEM major until graduation. Only Whites and Asian Americans had a better than average persistence rate within STEM majors. National Science Foundation statistics also show that African-Americans and Hispanics have a lower degree attainment rate compared to their freshmen intention of majoring in STEM. In 2003, 33.6% of African-Americans and 35.8% Hispanics entered college with an intended major in science and engineering. Six years later only 8.2% of African-Americans and 8.5% of Hispanics graduated with a science or engineering degree (NSF, 2012). These results are similar to those of a study done by Rath, Peterfreund, Xenos, Bayliss and Carnal (2007) showing the differences among students entering the biological and biomedical sciences. They found that of students between the ages of 18-29, only 15.3% of bachelor degrees in the biological sciences were attained by underrepresented minorities (URM) consisting of African-American, Hispanic and American Indian/Alaskan Native students compared to 22.9% of Whites (p.203). Similar studies done by Gasman, Perna, Yoon, Drezner, Wagner, Bose, and Gary (2009) and Anderson and Kim (2006) show the same percentages when comparing URM’s and the United States’ general population receiving a STEM degree.

The percentage of 9th grade students who went on to finish high school within the normal four years and complete a college degree at 150% of program time is only 20.5%. This means that out of 100 students who were in 9th grade in 1998, only 20 graduated
with a bachelor’s degree in 2008 (National Center for Higher Education Management, 2009). The lack of graduates within URM’s compounds the difficulty of building the 21st century workforce that is needed within the STEM fields. From 1994-2003, employment in STEM fields increased 23% (United States Government Accountability Office [GAO], 2006). During the same time period, there was a 5% decrease from 1994-95 to 2003-04 in the number of students attaining degrees in STEM fields (GAO, 2006). In addition, the GAO found there was still an underrepresentation of Hispanic and African-American employees in STEM-related work as compared to percentages within the general labor force (GAO, 2006).

**STEM Graduates within Two-Year Colleges.** Underrepresented minorities earn a bachelor’s degree at a lower rate than the White population, but is this also true at community colleges where there is a large population of underrepresented minorities? Nettles and Millett (2008) cite a huge increase in minority enrollment at community colleges in the United States over the past two decades, a 16% increase in African-American enrollment, an increase of 143% in Hispanic enrollment, and a 250% increase in the Asian/Pacific Islander enrollment. What is more significant is that the National Science Foundation reports that 50% of science and engineering four-year graduates first attended community colleges, with the percentage being higher for minority populations (Mooney & Foley, 2011).

The low number of STEM graduates from two-year colleges does not reflect a lack of STEM majors at college enrollment, but rather at degree attainment. Students are not graduating within a STEM field in sufficient numbers to meet the increased demand for STEM graduates among potential employers. This is particularly true for
underrepresented minority students. Between the 1995 graduating cohort and the 2004 graduating cohort there was an 8% increase in minority students obtaining their Associates degree. For the same time period, there was only a 4% increase in minority students obtaining a STEM degree (NCES, 2004, 1999). More recent data paint an even more compelling picture. From 2003-2007 there was a 24% drop in science and engineering associates degrees awarded to students, with African-American students showing the greatest decrease at 28% (National Center for Science and Engineering Statistics, 2010). Even though there was a dramatic increase in physical sciences and sciences technologies majors (27%), as well as a slight increase in students majoring in biological sciences and math, these results do not offset the major decreases in computer and information sciences, engineering, and engineering technologies.

Deutch, Jurutka, and Marshall, (2008) suggest that students who transfer to four-year universities from community colleges do not have the required science courses to adequately prepare them for the rigors of a STEM major. Students then overload on STEM courses to make up that deficit, thus accentuating a failure in these courses, and end up withdrawing from college. Anderson and Kim (2006) studied URM’s and found that there was a correlation between levels of social integration as well as working more than 15 hours a week and persistence of STEM majors to graduation. These two factors are critical at community colleges given that it is more difficult to socially integrate at a community college (Settle, 2011) and because large numbers of community college students work more than 15 hours per week (American Council on Education, 2006).
Student Services

One strategy to improve graduation rates within STEM is to provide support for STEM majors while these students are in college. Students are able to draw upon campus-based resources to help them through college, whether they attend a four-year university or a community college. The range of student support programs is as different as the colleges offering them. There are national programs, such as TRIO’s Student Support Services (SSS), and regional efforts, such as Math Engineering Science Achievement (MESA), which provide academic support to students with the goal of graduating students in STEM. There are also state-funded programs such as Educational Opportunity Programs or the Higher Education Opportunity Program in New York. Both kinds of programs assist educationally and financially disadvantaged students to be successful in college, and all of the programs provide some type of student support, whether it is academic counseling, tutoring, or assistance with financial aid and scholarships.

The services provided in these programs align with Astin’s (1985) Theory of Involvement, which states, “Involvement is the investment in physical and psychological energy that the student devotes to the academic experience” (Astin, 1985, p.36). In other words, for student growth to take place, students must be actively involved in their college environment. Astin proposed two additional postulates: 1) the greater the involvement in a program, the more student learning and personal development occurs, and 2) the more involvement a program requires of a student, the more effective that program will be for the student. Student service programs work to provide the connection between academics and involvement through the myriad activities they offer.
In addition to these national, state and regional government programs, there are a number of other student support programs funded by the National Science Foundation. There are two problems with all of these government-funded programs: they are criteria-specific such as for female students only, and they limit the number of students providers can serve. MESA and SSS programs serve 200 to 300 students. Many of the NSF programs serve as few as 50 students. In addition, many of these government-funded programs also have an income criterion as part of their application process. Consequently, although very worthwhile, these programs cannot assist the overwhelming number of students at four-year or community colleges who need academic support. For example, the U.S. Department of Education’s Student Support Services Program only serves 7% of the eligible population that can benefit from academic support while in college (Council for Opportunity in Education, 2011).

Tutoring is one possible strategy to help a large number of students to better their academic outcomes. Taking one of Astin’s (1985) postulates, if students are engaged in their educational growth by learning new concepts and receive assistance in tutoring, they are more apt to be involved (such as attending more office hours or creating study groups) in their own academic learning. A study done by Maxwell (1990) suggests that although tutoring works for the more academically prepared student, it does not consistently assist those students who are underprepared or weaker in academic skills. A more recent study by Laskey and Hetzel (2011) showed an improvement in GPA and retention for at-risk students when tutoring was used as a service, but Hodges and White (2001) showed similar results to Maxwell’s study, especially when students did not have a consistent amount of tutoring hours they attended during the semester. Thus tutoring
provides assistance to the academically stronger student, but it is not as effective for students who enter college with academic deficits.

In addition, even though services such as tutoring are available to students who may be academically deficient, students do not always choose to take advantage of these support services. Earlier studies, such as those conducted by Friedlander (1980), Karabenick and Knapp (1988), and Rosen (1983), demonstrate this behavior in students. A more recent study by Karp, O’Gara and Hughes (2008) also demonstrates that students who are academically disadvantaged at time of enrollment tend not to understand the importance of using these services to help them persist in college.

Because the emphasis of tutorial services is on helping students whose academic standing is low, a stigma may be created when students use such services (MacDonald, 1987; Zaritsky, 1994). Tutoring services used in STEM-related service programs may dilute the effect of stigmatization for the student given there is a general perception that STEM coursework is difficult and there is more need for tutorial services. The problem occurs when the tutoring is only available through programs such as MESA, which are not structured to serve large numbers of students and thus have a limited effect on the potentially 1/3 of the student population who enter college wanting to major in STEM. The irony of support programs is that the goal of student service programs is to help students succeed, but being part of one of these programs may stigmatize students to the point of not searching for these very same resources. In addition, any service that is STEM specific is usually limited in how many students can receive the service.
Supplemental Instruction

The answer may be Supplemental Instruction. In an effort to counteract the effects of low persistence within STEM majors, even within the general population, colleges have been providing services that help students succeed in their coursework. One method that is considered an exemplary educational practice by the U.S. Department of Education is Supplemental Instruction (SI) (Martin, Arendale, & Blanc, 1997). In 1972, the University of Missouri-Kansas City (UMKC) university-wide retention committee was searching for answers to respond to an increased attrition rate for the general college population and specifically for professional school students in pharmacy, dentistry, and medicine. The committee had negligible funding and it had to help students without adding remedial courses to the curriculum. Dr. Deanna Martin, a doctoral student at the time, was hired through a small grant from the city. She devised a plan that would satisfy both the administration and the faculty. In 1973 the first Supplemental Instruction pilot study occurred at the UMKC campus.

Supplemental Instruction sessions are provided concurrently with a particular course. The sessions are peer led by a student who has taken the course and received an A or B in the class. These sessions are voluntary and begin as each semester starts thereby minimizing any negative stigma related to remedial services by not separating students who are doing well in the course from those who are showing poor results via tests or homework scores. The SI leader attends the regular class sessions, takes notes and participate similar to a regularly enrolled student.

The leaders then act as facilitators in the SI session helping students focus on learning skills using the concepts taught during the lecture (Martin, Arendale, & Blanc,
The leader does not re-teach the lecture or specifically review the lectures; rather the SI leader helps the students through small group discussions about any concepts and assignments that may be troubling them.

Students also learn to emulate good study habits via the SI leader. Because the SI leader is in every class, he/she can then review the notes with the students in the SI sessions as well as assist them with reading comprehension and test-taking skills for the course. The SI leader does not hand students the answers. Instead small groups collaboratively answer any questions brought forth from the lecture and/or any questions developed by the SI leader. Within the SI sessions, students then teach each other the concepts learned from class or the study skills necessary to master each concept. An important part of the SI session is test preparation. When a test is about to be given in class, the students will predict what possible questions will be on the test as the SI leader draws from experience to help the group prepare for the test. The SI leader does not receive any test questions to review from the instructor, nor grade any exams.

The biggest difference between Supplemental Instruction and other student service programs such as tutoring is that SI is used for those courses in which students receive 30% or more D, F, W grades. It targets high-risk courses and not high-risk students; in fact, the more heterogeneous the SI session, the better the results (Congos, 1993). SI is used for high-risk courses in both graduate and undergraduate coursework as well as two-year colleges.

The first National SI Center was created at UMKC. Today there are SI Centers around the world and in almost every state. Colleges in Canada, England, and Australia also implement Supplemental Instruction. SI may be called different names in different
countries. Such as Peer Assisted Learning Support in Ireland (Parkinson, 2009). Over the years there have been variations of the original model, but Supplemental Instruction in its “pure” form consists of high-risk courses done on a voluntary basis with the SI leader being a student who has already succeeded in the course.

It is important to clarify the difference between Supplemental Instruction and tutoring. Both have tangible benefits and both are used at colleges, but there are definite distinctions between the two approaches. Tutoring can be one-on-one or group, but SI is always a group experience. Tutoring can be done by a peer, a student who has taken the course, or even a faculty member. SI is always done by a peer who recently completed the course and attends current classes again taking notes. During a tutoring session, the tutor will review a specific concept or assist with homework. In contrast, during an SI session, the SI leader will use a study skills strategy to help students master the concepts. The tutor is usually seen as the expert, but during the SI session, the SI leader helps students to teach each other. There is no single expert. Learning through peer teaching is the goal of SI sessions, as opposed to the primary goal of lectures and textbooks, which is to communicate information (Congos, 2003).

As the UMKC model was branching out into different colleges, a doctoral student, Uri Treisman, from the University of California at Berkeley was asking how to improve beginning calculus classes. He saw that African-American students were failing the course at a greater percentage than any other group of students. Through a survey developed to study minority performance in calculus, Treisman was able to determine four reasons why minority students were failing calculus: motivational gap, inadequate preparation, lack of family support/understanding of higher education, and low SES level
(Treisman, 1992). Nevertheless, Treisman felt there must be forces at play other than the four assumptions made from the survey and searched for other explanations of why minority students were failing calculus. He realized that Asian students were not studying by themselves, but instead they would gather in the evenings to teach and test each other. He used the model of peer-teaching and created The Mathematics Workshop to improve the success rate of minority students taking calculus and other math courses at Berkeley. The Mathematics Workshop is based on strategies similar to Supplemental Instruction. Treisman’s program resulted in over half of the students outperforming not only their minority peers, but also their white and Asian peers (Treisman, 1992, p. 369). Martin, the founder of SI, and Treisman, one of the first to use SI strategies in the western United States, are considered the leading experts on Supplemental Instruction.

The International Center for Supplemental Instruction, housed on the campus of the University of Missouri-Kansas City, compiles national data from its SI centers around the country. In its most recent report, Supplemental Instruction National Data: Fall 2003-Fall 2006 (University of Missouri-Kansas City, 2007), the results remain the same as when SI first started 35 years ago: students who utilized Supplemental Instruction had higher course grades and withdrew less from courses than non-SI participants. They also had higher graduation rates compared to non-SI participants.

**Supplemental Instruction and Retention**

Studies have shown that Supplemental Instruction increases both course GPA and overall GPA, but what about student retention? Does SI have a positive effect in reducing attrition among students? The International Center for Supplemental Instruction has shown that SI produces an increase in student retention with a reduction in D, F, and W
grades. The Center has further shown that improvement in retention outcomes also result from the use of SI in different subject matters such as accounting, calculus and biology (Etter, Burmeister & Elder, 2000; Horwitz & Rodger, 2009). Blanc, Debuhr, and Martin’s (1983) study revealed that utilizing SI for seven arts and science courses not only improved the course GPA and overall GPA, but also retained students over a period of four semesters at a 13% higher rate than non-SI users. Horwitz and Rodger (2009) studied an introductory computer science course in seven institutions over two years and found that when students used SI there was a 6% increase in retention. Additional studies have led to the same conclusion: there is an increase in retention rates for students utilizing SI as a resource while in a particular course (Blat, Myers, Nunnally, & Tolley, 2001; Ogden, Thompson, Russell, & Simons, 2003; Parkinson, 2009).

While studies cited above discovered that course GPA was higher and overall GPA increased, their results raise the question: when utilizing SI, did the students transfer the learning skills from the course that supplied SI as a resource to other courses the students were taking that semester? What has been minimally evaluated is the mechanism to transfer the skills of SI from one course to other courses. Jarrett and Harris’ (2009) study suggests that these skills are transferrable and in fact, students use the skills learned in SI for other classes. Sixty-two percent of students who utilized SI for the world civilization course transferred these skills to other courses with 77% of these students feeling that the transfer of skills was useful with other coursework (p.38).

Another informative study regarding SI and retention was done at a four-year land-grant university to see if SI had long term effects over a four-year period. For this study, the student population was disaggregated into four cohorts: Traditional SI,
Traditional non-SI, Program SI, and Program non-SI students. The traditional students were those students who were deemed “college ready” through SAT results, admission status, class standing and prior units completed. The Program students were those students who did not have the required learning skills to do well and were conditionally admitted, or who were part of a student service program. The results were similar to national data (Martin, Arendale, & Assoc., 1994), but the study also found that students within the Program SI cohort had higher course GPA than Program non-SI students and had the highest persistence rate of all four cohorts even though they came in with less pre-college preparation (Ramirez, 2007, p. 4).

Most of the literature on the subject of Supplemental Instruction is based on four-year colleges and universities. Numerous studies have demonstrated the effectiveness of SI in increasing course GPA and overall GPA (Blanc, DeBuhr & Martin, 1983; Blat, Myers, Nunnally & Tolley, 2001; Lyle & Robinson, 2003; Phelps & Evan, 2006; Wright, Wright & Lamb, 2002) at the four-year institutions. Upon further investigation, there is some literature of note focused on community colleges that also proves increased course GPA and retention of students who utilize SI. Wolfe’s study conducted in 1991 used SI within the math, science, social-science and computer science community college departments and found a significantly higher success rate for students who were SI participants (78%) versus non-participants (44%). Zoritsky and Toce (2006) also found SI to be successful at community colleges. Most often, research on SI within community colleges concentrates on developmental courses even though SI is primarily used for college-level courses. Arendale (1987) suggests that SI may not be as effective when used in developmental courses because students in these courses enter college with a lack
of academic skills needed to be successful in college. “Second, SI has not been effective for students who cannot read, take lecture notes, write, or study at the high school level. Therefore, we stress to adopting institutions that they use SI in non-remedial settings with high risk, demanding courses (Arendale, 1987, p. 3). However, developmental courses are more prevalent at community colleges and several researchers have found SI to be effective for students taking developmental courses (Peacock, 2008; Phelps, 2006).

The Long-Term Effect of Supplemental Instruction on STEM Students

Supplemental Instruction has been studied at both four-year and community colleges. Research has been conducted in both STEM courses and non-STEM courses. All of these studies show a positive correlation between SI and increasing both course GPA and overall GPA. SI has also been studied to see if there are any short-term effects on overall GPA and retention to graduation. However, as of this writing, there is a dearth within the literature on the subject of any long-term effects Supplemental Instruction might have on STEM students. To date, I have been able to find only three studies about any long-term effect of SI on students’ GPA (Parkinson, 2009; Ogden, Thompson, Russell, & Simons, 2003; Ramirez, 1997). All three studies were conducted at four-year universities and they only researched singular courses (non-sequential) and sought to determine if there was a sustaining effect on overall GPA. It is important to note that Ogden et al.’s study revealed that students who utilized SI during fall semester of their first year had a decrease in overall GPA over a period of two academic years. Ogden et al.’s suggestion for further study of the possible use of booster SI sessions led me to undertake this current study. I could not find any literature about studies on the effect of
Supplemental Instruction within a course sequence of STEM courses at community colleges.

This study within this dissertation tried to fill the demonstrated knowledge gap by answering several questions:

1A. Is there a difference in course grade between community college SI participants and non-participants in a STEM course and how does SI affect student grades within developmental coursework?

IB. Does participation in SI for a development-level STEM course have an effect on the grade in the subsequent course in the sequence?

2A. Is there a difference in course grade between community college students who utilize SI in a sequence of STEM courses as opposed to one course?

2B. Is there a difference in course grade between community college students who utilize SI in two STEM courses within one semester as opposed to one course within a semester?

3. Is there a difference in successful persistence within a STEM course sequence when utilizing SI versus no SI?

**Importance of Study**

The importance of studying SI at a community college within a sequence of STEM strands is three-fold. First, most community college students enter the institution without the proper preparation of study skills to succeed in STEM coursework in college (Moore & LeDee, 2006; Phelps & Evans, 2006). Supplemental Instruction teaches study skills within the context of the class. Students are able to directly apply what they have learned in SI to the concepts they are learning in their class lecture. It has been shown that SI has
its underpinnings with constructivism, taking what knowledge is available and adding to this knowledge to create new knowledge. SI has already been shown to increase course-content knowledge by improving students’ study skills. What is missing in our understanding of SI’s benefits is whether increased learning of study skills from participating in SI for two semesters translates to additional mastery of course content as shown via higher grades in the second course. Secondly, SI students learn critical thinking skills, a necessary component to any higher-level college class (McGuire, 2006; Widner, 1994). These critical thinking skills can be used specifically to help students continue to better their course grade when the subject matter is within a required sequence of courses, such as Biology 1 and then Biology 2. This study will also try to determine whether there are diminishing returns to a student’s second semester of SI, either in a consecutive or sequential course. This will help colleges decide where their attention and reduced funds can be most effectively used.

Third and last, SI assists with retention and overall performance. Does this effect still hold true when students are required to take a series of courses within a departmental strand? With the continuing budget crises that are affecting all schools, including community colleges, it is important to evaluate which programs are effective and have long-term impact. As stated earlier, with almost 50% of students who graduate with a STEM degree starting at community colleges, it is important to not only maintain but also increase the number of community college students who are able to transition to four-year colleges in STEM. Researching SI as a viable solution to assist all community college students within STEM can help both the student and college in the retention process. With a plethora of outreach services to the students at community colleges, it is
important to find out if this program benefit the most students and have the greatest effect on retention and graduation of STEM majors.

This study will add to the knowledge base of successful student services programs in general, and can specifically demonstrate how Supplemental Instruction can be used by STEM programs within a community college. As stated earlier, with the push to encourage more students to enter the STEM fields coupled with a more diverse population needing expanded educational services, Supplemental Instruction may prove to be a positive support program for community colleges. Support programs such as Supplemental Instruction are usually the first programs to be cut when there is a lack of funding at the institution. This study will help guide institutions who use or who are interested in using Supplemental Instruction by providing a structure on how SI can benefit the most students.

**Definition of Terms**

1. **Attrition**: The rate of students not persisting until graduation.

2. **Course Sequence**: The selection of courses within a given academic department that a student is mandated to take in order to continue to the next course.

3. **Historically difficult courses**: Courses in which there is a record of greater than 30% W, D, F and withdrawals.

4. **Successful Persistence**: Earning an A, B, or C in two consecutive courses in a sequence.

5. **Remedial/Developmental**: Courses taken by students who do not meet the “college-ready” criteria of a particular college; these courses precede college-credit course work.
6. Retention: The rate at which a student completes a course with a C or better.

7. SAT: Scholastic Aptitude Test, a standardized college admissions test

8. SI: Supplemental Instruction; a support service developed by Deanna C. Martin at the University of Missouri Kansas City in 1973 which uses learning skills to assist students with mastering concepts in a class.

9. SI Leader: A student who received an A or B in a course who then facilitates the SI session for the same course the following semester or year.

10. SI session: A study group conducted outside of normal class hours and facilitated by a SI leader; during the session students learn to integrate study skills with content matter.

11. URM: Underrepresented minorities, which for the purpose of this study will include African-American, Hispanic and American Indian students.

**Limitations and Delimitations of Study**

Due to the specificity of this study, the results may not generalize to all community colleges and/or four-year colleges. This study was conducted at a community college whose area is considered suburban. There may be an external threat to the validity of the study given that the ethnic/racial makeup of the data set is not known. There is no way of telling if there is a predominance of one ethnicity/race over another ethnicity/race. Another external threat is that Supplemental Instruction can be offered in any subject, but this study will only research the course sequence within math, biology and physics. This study cannot assume the same results for other courses within the community college.
A possible internal threat is the number of students who start the sequence of courses compared with the number of students who finish the sequence utilizing SI throughout the sequence of courses. This created a low \( n \) value for the study. Because SI is voluntary, self-selection may be a factor. Both Gattis (2002) and Bowles and Jones (2003) discuss that self-selection may occur with the more motivated students attending SI sessions in order to be successful in college. Although Bowles and Jones’ research suggests that it is the student with below-average ability who attends SI sessions, and not the student who is already highly motivated and receiving good grades, nonetheless, self-selection can be limiting for this study.

**Overview of Dissertation**

This dissertation will contain five chapters: Chapter 1-Introduction, Chapter 2-Literature Review, Chapter 3-Methodology, Chapter 4-Data Analysis, and Chapter 5-Discussion and Conclusion. Chapter 1 includes an introduction to the problem of STEM education in the United States and discussion of the decline in STEM education among URM’s. Chapter 2 provides an in-depth discussion of the literature regarding STEM education using thematic elements to present the current problems of both high school and college-level STEM education as well as the effect of SI on college courses. Chapter 3 discusses the quantitative methods that will be used to conduct the research. Chapter 4 includes data reporting and data analysis using the methods presented in Chapter 3. The last chapter will discuss the new-found results and conclusions based on the research. Possible further research will also be addressed in Chapter 5.
Chapter II

Literature Review

In California alone, there were 135,232 awards (degrees and certificates) conferred by community colleges for the 2009-2010 academic year, yet out of all of the awards conferred, only 3,801 or 2.8% of those awards were associate degrees in STEM majors (California Community Colleges Chancellor’s Office, 2011). This is far below the numbers needed to sustain a competitive edge in today’s global economy (National Science Board 2003; Scott, 2010). National statistics are not much better. According to the National Center for Education Statistics, 750,164 associate degrees were awarded during the 2008-09 academic year yet only 8.8% of all community college students graduated within a STEM field. Community colleges have tried to lessen the gap through support services such as the state-funded Math, Engineering, and Science Achievement (MESA) Program or through federal grants from the National Science Foundation such as the Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP). Yet there are still not the number and “quality of ‘knowledge workers’ whose specialized skills enable them to work productively within STEM industries and occupations” (U.S. Department of Labor, 2007). The availability and number of services accessible to community college STEM students are still a problem.

This literature review will thematically follow previous discussions and research regarding the lack of students in STEM at community colleges and how Supplemental Instruction (SI) may be one possible resource for correcting the problem. The topics will include: high school factors predicting students going into STEM majors; persistence
within the STEM major; community college and developmental education, and then
Supplemental Instruction including the educational theories that relate to SI.

Pre-College Demographic Factors

Multiple factors may contribute to a STEM major not being selected as a major of choice. Many of these factors involve college preparation. Jacobson (2004) states that large numbers of students are not prepared for college level work. Citing an ACT report "Crisis at the Core: Preparing All Students for College and Work," Jacobson argues that only a quarter of the students who took the ACT were ready to earn a C or above in their first college biology course, and less than 1/2 of the students were ready to earn a C or higher in their first college algebra course. Chief Executive Officer of ACT, Richard Ferguson, (2005) stated a similar opinion, “Our research also confirms that taking and doing well in specific [high school] courses—such as Biology, Chemistry, Physics, and upper level mathematics (beyond Algebra II)—has a startling effect on student performance and college readiness” (p. i).

High School Curriculum and Grade Point Average. In the NCES report (National Center for Education Statistics, 2009), the stronger the academic preparation in high school, the higher the completion rate of students within STEM majors. NCES found several predictors of success in college, including rigorous high school courses (such as pre-calculus and calculus) and a high school GPA of at least 3.0 Looking at a multitude of variables including background characteristics and intended major choice, Sax (1992) discovered that better high school preparation was one of the factors that contributed to better persistence within the hard sciences.
**Socio-Economic Status (SES).** At low SES schools, the challenges faced by their students outside of the classroom are a detriment to the learning process. In a study conducted by Guskey (1997), the largest single factor causing a variation in scores at all school levels was the percentage of students qualifying for free/reduced lunch (p.2). There is an increased correlation between socioeconomic factors and student achievement in the higher grades of secondary school compared to the lower grade levels (Gusky, 1997). Sutton (2001) looked at the Illinois school system and found somewhat similar results: the higher the SES, the better the achievement scores, suggesting that SES is a strong correlate to math achievement (p. 336). Students with low SES levels never gain momentum in their learning to catch up to higher SES students as they progress from elementary school to high school, and if students attend low SES schools, their learning growth patterns further decrease compared to higher SES schools (Ma & Wilkins, 2002). This is true for all levels of science: biology, physical and environmental science.

California also faces the same woes as other states when it comes to educating low-income students. From birth, low-income students have less access to quality educational programs. By the time these students enter elementary school and then continue on to middle and high school, their schools become more stratified with fewer quality teachers, smaller numbers of resources, lower performance on tests, and most important, less focus on college readiness (Scott, 2010).

Scott also stresses that preparing students who want to major in STEM is problematic for many low SES high schools. The low SES schools do not have the credentialed instructors to teach math and science. Even if the teachers are available, there is little equipment, and few labs and textbooks for the students to use in their
classes (Scott, 2010, p. 5). These same students try to enroll in STEM majors in college and many fail because they were not adequately prepared in high school.

Another way to examine correlations between SES and proficiency is to examine the literacy of a student within a certain subject. This type of test is used to examine how well a student applies the content of a particular subject. The Programme for International Student Assessment (PISA) tests literacy skills of 15 year olds from 57 countries around the world in reading, math, and science. Willms (2010) studied science literacy based on the PISA, and used both horizontal segregation, or, “the extent to which students from differing SES backgrounds are distributed unequally across schools” (Willms, 2010, p. 1011), as well as vertical segregation, which is based on diverse performance among actual schools due to tracking of students into particular programs. The study suggests that although there were average and high SES students scoring at a low level, as well as resilient students from low SES backgrounds who scored at higher levels, SES has an influence on student performance on the PISA. The report also includes a moderate correlation (.36) between SES and science instruction time indicating lower SES students have less time learning about science than those in high SES schools (p. 1024).

SES matters with regard to literacy in math and science while in high school. The lower the SES, the less math and science literate are the students. Although Willms saw that several lower SES students made it to the higher levels of the PISA ratings, these students were the exception and not the rule. As shown earlier, without success in learning higher-level math and science skills, these same students will not be successful in STEM majors. Many will not choose STEM majors even if they go to college.
Parental Education. Longitudinal data show that a mother’s education correlates to math achievement scores (Newton, 2010). A 1% decrease in the mother’s educational attainment resulted in a 6% decrease in math achievement scores by the end of high school. Even students who have high math achievement scores in 7th grade lose that edge by the end of high school if their mother has a low level of education. Students who are first-generation (FG), meaning neither parent went to college, were less likely to take higher levels of math while in high school and only enrolled in college at a rate of 32% compared to 63% of students who had at least one parent graduate from college (NCES, 2000). This was true even if the non-FG student did not take higher levels of math while in high school.

Even if FG students were highly qualified, approximately 25% did not enroll in a four-year college and 13% did not enroll in any college (p.26). In contrast, only 1% of highly qualified students from families with parental graduates did not enroll in college. These statistics equate with wanting to go to college; FG students had a lower desire to attend college compared with students from families where the parents had some college and those from families where the parents had a bachelor’s degree-29%, 37%, and 46% respectively, (NCES, 2000; Olive, 2008). Studies done by Hossler and Stage (1992), Stage and Hossler (1987), and Manski and Wise (1983) all suggest that the level of parental education influences whether a child even thinks about attending college, much less does well in college. Parental education is an important variable for student achievement in college.
Persistence within the STEM Major

**General Persistence.** Studies have shown there is a dramatic drop in the number of students graduating college with a STEM degree from those who started college in a STEM major. The percentage of students who started college in a STEM major in 1995 and persisted to graduation in STEM by 2001 was only 41% (NCES, 2009). An additional 21% of students who started in STEM switched to a non-STEM major before graduating. The rest left college altogether. The difficulty level, whether students attend liberal arts colleges, research universities or highly selective colleges, is a major reason for students not persisting in STEM (Strenta, Elliott, Adair, Matier, & Scott, 1994).

Even at highly selective colleges, where students are more academically prepared, 40% of the students who were initially STEM majors did not graduate within the STEM fields. According to Strenta et al. (1994), “differences in persistence were attributable to a significant degree only to single performance variable, grades in science courses the first two years” (p.541). The initial gateway classes for STEM majors such as biology, chemistry and calculus actually inhibited students from persisting in a STEM major. Most felt the classes too competitive with instructors not being responsive to questions.

Students who receive high grades in STEM classes, particularly their first STEM class, will continue to take additional classes in STEM and stay a STEM major, but if students receive higher grades in non-STEM classes, they tend to reclassify their major to a non-STEM major (Ost, 2010; Rask, 2010). Mean STEM grades are normally lower than mean grades from other departments and usually fall below the average mean grade for all departments. Higher grades in the first STEM course will increase the odds for a
student to take a second STEM course. (Rask 2010). Ehrenberg (2010) also found that persistence in STEM relates to course performance during the first two years.

Low persistence within STEM is a major problem and many colleges are targeting the first year as a critical point in keeping students retained in STEM majors. Many students do not understand the commitment it takes to complete a STEM major, or do not have sufficient background knowledge to compete in the gateway classes for STEM. Even when students have the background and the drive to pursue a STEM major, antiquated pedagogical methods employed by professors make it difficult for students to persist in STEM. As Wheatley et al. (2007) point out, “Attrition includes students who are unprepared for the demands of STEM curricula as well as talented undergraduates who choose other disciplines with more creative instructional delivery methods” (p. 2). Wheatley et al.’s study looked at collaboration between a four-year university and a community college to enhance persistence among STEM majors. As seen in Crisp et al., Wheatley et al. also saw the gateway classes becoming a barrier to women and underrepresented groups. Calculus, the gateway course sequence class for first-year engineering students, is a major contributor to students’ decisions to discontinue studies in the area of engineering with 58% switching majors or leaving the university before ever finishing the calculus sequence.

Relation of College Retention and Supplemental Instruction. Supplemental Instruction is geared for non-competitive interaction and for asking questions that students were too afraid to ask in classes. Different researchers view different years in college as the critical point for students to commit and stay in STEM. Strenta et al. (1994) suggest that students in STEM majors have a difficult time persisting through to their
junior year although Sawyer (2008) reports that there is a correlation between persistence to the sophomore year and graduation. A study completed by Hurtado, Chang, Saenz, Espinosa, Cabrera & Cerna (2006) suggests that a student’s first year is the most critical. They cite Tinto (1993) and Nora (2001) when they add that the first year sets the stage for the remaining undergraduate experience (p.4). It is usually the gateway classes taught within the first two years which are the courses that have higher than normal D, F, W rates. SI specifically targets these gateway courses and helps students overcome the difficulties of the course work.

It is not only the extrinsic assessment through grades that affects persistence, but also “…academic adjustment has much to do with a student’s intrinsic assessment of his or her relative success in navigating a new academic environment” (Hurtado et al., 2006, p. 843). In other words, when students feel good about their success, particularly within the first year, there is a greater sense of belonging, which in turn brings about greater self-worth, thus greater academic success, and the cycle starts again. Conversely, when students experience isolation within their major because of their lack of success, their sense of belonging decreases; thus there is a further decrease in academic success.

As with Strenta et al. (1994), the study prepared by Hurtado et al. (2006) also showed greater stress among students attending highly selective schools. They found that students had lower levels of academic success during their first year due to lower levels of perceived sense of success. For underrepresented minority students, attending a Minority Serving Institution (MSI) correlated with a sense of achievement and well-being, regardless of major (DeSousa & Kuh, 1996; Flowers & Pascarella, 1999; Watson & Kuh, 1996). Yet Hurtado et al. found that attending a MSI or even a campus with a
greater number of STEM students did not contribute to a sense of belonging. The STEM Majors at MSIs had a lower sense of achievement and well-being than students who were in their same racial/ethnic group, but who were non-STEM majors (Hurtado et al., 2006). What is important to note for this current study is that students’ academic achievement had a significant effect upon their sense of success and managing the environment (p.866). Students need to feel successful during their first year if they are to integrate within the college community and persist until graduation.

The most pivotal piece of information related to SI is the last section of Hurtado et al.’s study, the ability for students to control their own college environment through activities such as taking classes in experiential and active learning. Astin (1996) added to his original theories and found that involvement with academics created positive involvement within the campus community. Davis (1991) found that positive involvement through peers and faculty decreased the dropout rate for African American students. A similar result was found by Taylor and Howard-Hamilton, who showed that greater involvement in academics led to a more positive racial identity which was then linked to student persistence (Hughes, 1987; Sedlecek, 1987). Berger and Milem’s 1999 study on student involvement suggests a positive correlation between peer involvement and academic integration which leads to greater persistence, although peer involvement had a stronger effect on social integration than academic integration. Supplemental Instruction is peer-to-peer learning and thus allows the student to control what he/she learns. Although there is an SI Leader who facilitates the session, it is the students who teach themselves and take charge of what is important to them. Just as important, SI is
not competitive, even within STEM SI sessions. This is not true of STEM majors in general where competition is a key factor.

**Community College and Developmental Education**

Developmental education is not new, but rather was available to students when the first colleges came into being in the United States (Wilmer, 2008). As early as the late 1800’s, the Ivy League schools hoped that high school students would be better prepared to enter college after the National Educational Association provided guidance on high school curriculum. Even with the guidance from the NEA, students were still unprepared to meet entrance requirements (Stephens, 2001). Grimes and David (1999) showed in the 1990’s there was no demographic difference between the unprepared and college-ready students; however, there were differences in academic preparation, attitudes, self-expectations, and values. They concluded that colleges must provide more than academic skills; they must provide holistic services to students.

When colleges had their pick of college-ready students in the 1960’s, community colleges filled the gap for those who still wanted a college education but were not able to attend a four-year university. Today, community colleges still play a major role in the education of students in the United States. Currently one-third of all college-bound students starts at or attends community colleges. Yet, the graduation rate of students finishing community college in six years stands at only 30% (Radford, Berkner, Wheeless, & Shepherd, 2010). Community college students needing developmental coursework have a graduation rate lower than the normal community college population and the previous dropout rate for students requiring developmental classes of 50% is increasing (Adelman, 2004).
The American Association of Community Colleges (2000) conducted a survey regarding developmental education and found that approximately 36% of first-time freshmen were enrolled in at least one developmental course. In California, only 15% of students test into college-level math with the largest percentage of students testing three levels below transfer-level math or the equivalent of pre-algebra (California Community College Chancellor’s Office [CCCO], 2012). As a result, only 14% actually complete any type of transfer-level math (CCCO, 2012).

Many community colleges offer services to their students, such as group and individual tutoring, math and English labs, and on-line tutorials, with the goal of achieving academic success. Although many developmental students take advantage of support services offered by the college, these services may not be sufficient to the meet the needs of academically unprepared students (Rutschow & Schneider, 2011).

Theory Behind Supplemental Instruction

There are several theories as to why students do better in their classes when they utilize Supplemental Instruction. The first is the Student Development Theory developed by Chickering (1969), Perry (1970), and Astin (1984). They theorized that the development of students is not just found within the classroom, but also includes the environmental and social aspects of college. Chickering (1969) built his model on a pamphlet entitled The Student Personal Point of View, first written in 1937 by the American Council on Education. The model points to seven paths or vectors of student development in college and moves from developing competence to developing integrity. SI correlates to the first four vectors. SI develops intellectual competence, the first vector, by helping the student learn the skills of analysis and synthesis.
With the second vector, managing emotions, students develop a more participatory inclination as opposed to inappropriately releasing pent-up emotions. SI uses peer-led instruction where frustrations from the class can be released in more appropriate ways through learning and understanding. Vector three, moving from autonomy toward interdependence, provides the student with the understanding that he/she can no longer be solely dependent on family, but rather can form bonds of interdependence based on equality and mutual exchange. Being peer-led and having students help each other is a main tenet of SI. Students do not rely solely on the instructor for all the answers but rely on their own strengths and the strengths of their peers.

Developing mature interpersonal relationships is the fourth vector in which students tolerate and appreciate the differences of others. SI is voluntary and based on course difficulty rather than on student remediation, thus students who attend SI are multi-ethnic/racial and have varying degrees of intellectual growth. Because the students work in groups and these groups change based on participation in each SI session, students within SI learn to tolerate and understand the differences of their group members.

Perry’s (1970) theory on student development saw entering college students having a dualistic point of view. Perry proposes that college students enter through nine stages of developmental and moral progression from the first stage (where there are right and wrong answers, so it is up to the student to learn the right answers) to the final stage where the student integrates the information learned from professors and peers with shared personal experiences. This theory connects with the SI session. The SI session is not led by a member of the faculty, but rather peer-led. The SI leader has a general goal
for the session, but the students in the session are the ones learning and teaching at the same time. The SI session is not an additional lecture, but an avenue where students are able to come to their own conclusions regarding problems that are directly related to the class. Because SI starts from day one of class, students begin to learn the introductory concepts taught during the first few weeks of class through basic strategies, such as proper note-taking and summarizing the day’s notes. As the class begins to move to more difficult concepts, the SI sessions begin to use higher learning skills such as critical thinking through small group discussions and teaching each other. The SI sessions go through their own progression to match the progression of the lectures.

Astin’s (1984) model of student development spoke of the amount of energy, both physical and psychological, that a student uses when in college. The greater the involvement in an institution, the greater academic success a student will have at that institution. Astin’s theory included five postulates: 1. Involvement refers to the physical and psychological energy in various objects; 2. Involvement occurs along a continuum within the same object (such as studying for a biology test) and between objects; 3. Involvement has both quantitative and qualitative features; 4. The amount of student learning and development associated with any educational program is directly proportional to the quality and quantity of student involvement; 5. The effectiveness of any educational policy or practice is directly related to the capacity of that policy and practice to increase student involvement. Once again, Astin’s postulates correlated with Supplemental Instruction. Although SI is voluntary, the student makes a commitment to attend outside of class. The student commits to working in groups and learning new study skills. The session is not rote, but demands higher level learning skills from a student. SI
is offered two-three times per week for the semester or quarter so students may potentially add an additional 48 hours onto their schedule. This extra time outside of class and with fellow students provides an opportunity for greater involvement of the student, thus, according to Astin, allowing students to achieve greater academic success.

The second set of theories, constructivist theory and collaborative learning, is based on student engagement and active learning. Constructivist theory is a pedagogical approach, an epistemology and a framework of interpretation (Airasian & Walsh 1997; Kindsvatter, Wilen, & Ishler 1996; Maddux & Cummings 1999; Noddings, 1995). Grendler (2004) described it as individuals constructing a reality that is valid based on their history and viewpoint. The meaning placed on a concept may be derived from the external world, but other constructivists state the meaning originates solely from the internal reality of a person (Bruning, Schraw, Norby, & Ronning, 2004). Harlow, Cunmmings, and Aberasturi (2006) suggest that a concept and its meaning for the person is the integration of both the independent reality of the external world and the mental concepts of the internal person (p.42). Views from the external world can be gathered and then critically processed to be accepted, rejected, or integrated and refined (Harlow et al., 2006)

Piaget (1952) developed a constructivist theory about how students learn: students construct knowledge through the interaction with the external world. The actions can be physical such as kicking a ball, or conceptual such as understanding negative and positive numbers. The student will try to integrate the new object (concept) into their own schema of their world. If the object cannot be easily integrated then disequilibrium occurs and the student is motivated to return to the equilibrium state by adapting the current schema for
a new schema that does incorporate the object. The cycle continues each time a student is faced with a new experience thus constructing knowledge. The learner is not passive and just assimilating information, but rather active as new knowledge has to be integrated into the internal world view and a new world view has to be developed. Piaget believed that knowledge is not a closed unit, but rather always evolving and open to change.

Present day constructivists such as Kincheloe (2000) and Thayer-Bacon (1999) continued with the idea that the learner is not passive, nor does knowledge come to the learner, rather the learner is actively involved in constructing new knowledge. Windschitl (1999, as cited in Gordon, 2009) stated that “constructivism is based on the assertion that learners actively create, interpret and reorganize knowledge in individual ways” (p. 39). Teaching therefore should involve experiences where the student is an active participant in the learning process and should include inquiry-based and collaborative learning in order that the student can makes sense of the new material (Gordon, 2009).

Vygotsky’s (1978) idea of constructivism was different than Piaget’s, for it included a social element. Vygotsky’s Zone of Proximal Development is “…the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p.86). Vygotsky thought that new knowledge is not only learned solely by an individual, but also by what the student can achieve while under the support of teachers and peers, thus through a social context. The acquisition of knowledge could change based on the cultural context the person is in while obtaining the knowledge. Vygotsky believed that knowledge is achieved, first through the social context, and then through one’s own conceptual schema. The context
of learning can be different with different cultural experiences. The more cultural experiences students have, the greater the opportunity to learn through this social context, thus teachers need to embrace diversity in the classroom as well the diverse methods of how students learn (Woolfolk, 2004).

Vygotsky applied his theory to the idea of scaffolding (Vygotsky, 1962). He believed that teachers should not only assist students with what the students can learn at the present time, but that teachers should use scaffolding to help students master the next level of the concept. Scaffolding is helping the student learn new concepts and move beyond any independent skills through supportive resources. This scaffolding is done through the support of the teacher or a peer who has already mastered the concept. The scaffolding is complete when students are able to take the knowledge they have (present step) and integrate new-found knowledge with their present knowledge with assistance (next step). The support system will not solve the problem, such as learning how to count to ten, for the student, but instead support the student while the student solves the problem.

Yet, Davis and Sumara (2002) believed that theories created in the discipline of psychology are hard to transfer to education because those theories are based on different concerns and goals. They also believed that the constructivist theories based on Piaget and Vygotsky do not provide practical advice to teachers and are used more for critiquing the current situations within a classroom. Cohen (1988) believes that teachers may inappropriately use constructivism in their classrooms. Pedagogically, constructivist activities require more time and energy to construct, something that may not be wanted by parents and teachers alike. Some teachers and parents prefer “back to basics” of pencil
and paper learning and testing despite the fact that those methods fail to take into account how a student learns (through interaction with self and others) and where the student learns (classroom and community (Oakes, Quartz, Ryan, & Lipton, 2000).

Freire (1994) on the other hand, believed in the concept of marrying cognitive and social constructivism. Gordon (2009) argued for Freire’s concept of marrying the two constructs. “Knowledge is attained when people come together to exchange ideas, articulate the problems from their own perspectives, and construct meanings that make sense to them” (Gordon, 2009, p.53). It is the process of inquiry which people take to understand the world around them.

Supplemental Instruction pedagogies are consistent with the theories of constructivism (Rabitoy, 2011). The group is the primary source of knowledge and group members must rely on each other to develop new knowledge. The SI leader does not lecture, but rather engages the student and his/her understanding in a particular subject thus demonstrating active learning (Congos, 2001). The sessions assist students with their own sense of knowledge and the capacity to be the authority of their own learning. SI allows students to start at their own level of comfort and moves the students toward being self-reliant in their own learning skills.

felt that social interaction and the exchange of ideas needed to start in the classroom. Kuh, Pace, and Vesper’s 1997 study showed that collaborative learning showed a positive effect on educational gains. Slavin (1995a, 1995b) suggested that when students come together in group interactions, they learn new strategies about the concept they are discussing and about thinking in general. Cooper (1999) believed that collaborative learning is one of the most effective ways to develop new knowledge. SI integrates the theory of collaboration with practical applications through the constant interaction of students with the SI leader as well as among themselves in smaller and whole groups (Burmeister, 1996).

In applying the theories of Vgotsky and Freire to Supplemental Instruction, especially for community colleges, Tinto and Russo (1994) have been able to positively correlate collaborative learning programs as an effective form of social integration within community colleges. Supplemental Instruction, a type of learning community, has been identified as having more impact on student outcomes than other types of learning communities (Kenney & Kallison, 1994; Tinto, 1997). Maxwell (1998) studied these types of interactions such as “joining a study group” and their impact on peer relations at a community college. Using a modified form of SI (instructors and financial aid counselors as SI Leaders instead of peers), Maxwell found a moderate correlation showing that students who took part in the SI session were more likely than other students to also join other study groups outside the sessions ($r = .24$).

Maxwell’s research brings to light that SI may have an impact, not only upon social interaction with other students, a key factor of social integration as found by Hurtado et al., 2006, and Weatley et al., 2007, but also upon what happens during and
after a student is involved in Supplemental Instruction. Maxwell’s study may indicate that SI provides for increased social interaction after the sessions, which increases a student’s sense of success. Students who engage in studying with other students have a stronger connection to the social culture of the school. This is one of the variables that create academic success through retention (Blat, Myers, Nunnally, & Tolly 2001; Hurtado et al., 2006).

**Supplemental Instruction and its Effectiveness**

What is important to this present study is the achievement of students. Studies have shown that students who achieve better grades in one class are more likely to be retained in college as well as pursue additional classes in the subject area (Lloyd & Eckhardt, 2010; Tinto & Russo, 1994). The research done by Blat et al. (2001) showed that SI had a positive impact on students moving from sophomore to junior and junior to senior status in college. There was a 10-point increase in retention from 79% to 89% in both sophomore to junior status and junior to senior status.

Critics of SI studies claim people who attend SI do so because of self-selection, and it is self-selection and not SI that is the cause of higher GPA’s. The more motivated students would select to attend SI, thus their class grade would be higher than those students who did not attend Supplemental Instruction. Blanc, DeBuhr, and Martin (1983) investigated whether there was a self-selection bias in SI. Their sample consisted of students who took SI, those who wanted to take SI but could not due to scheduling conflicts with work or other classes, and those students who were not motivated to take SI and did not attend any sessions. Motivation was accounted for through students who wanted SI, but could not attend due to conflicts in work or class schedule. Blanc, Debuhr,
and Martin showed that motivation was not the only factor in the increase of course
grade, semester grade and the percentages of D, F, and W’s within the class. Once again,
the factor of self-selection was proven false because the motivational control group (who
wanted to attend SI sessions, but could not due to scheduling conflicts) had lower average
grades, lower semester grades and higher number of D, F, and W grades than students
who received Supplemental Instruction.

Other studies also look at self-selection. Parkinson’s (2009) study done in Ireland
using peer tutoring tested whether self-selection was a factor for higher GPA’s. Even
controlling for self-selection, Parkinson found an increase of course GPA at the end of
the semester. Parkinson’s study showed a long-term effect of SI, with higher grades over
the second semester compared to non-SI students in calculus, inorganic and organic
chemistry, and physical and analytical chemistry. Although controlling for the effects of
certain variables, the students selected the amount of time for SI sessions (one or two
hours/week) and students had an opportunity to be individually tutored by the
mathematics department. These two variables may have skewed the positive results of SI,
because students in SI could also receive additional assistance in tutoring.

Blat et al. (2001) invalidates the myth that only “good students” attend SI (no p
#). Their data compare average math and verbal SAT scores as well as predicted GPA,
ethnicity and gender and they found that the data of the students who attended SI were
reflective of the general population of the school. The study conducted Supplemental
Instruction sessions on several courses in the Engineering Department, which included
Statistics, Mechanics of Solids, Network Theory II and Applied Calculus. Their work
showed that SI had a statistically significant impact on reducing D, F, W rates. It also
showed that although the A, B, and C grades for most of the courses were not positively affected by SI, Supplemental Instruction made the difference between students passing or failing the class (Blat et al., 2001).

Both Xenos et al. (2007) and Hensen and Shelley’s (2003) studies showed that while students who utilized SI had lower college entrance test scores and lower high school GPA’s, they outperformed the general students in the same class. Blanc et al. (1983) continued their research with persistence and found there was an increase in student persistence between the SI and non-SI groups. After two semesters, 73% of the original SI student sample was still enrolled versus 60% of the non-SI sample.

**Credit-Bearing STEM and Non-STEM Classes.** This study will use data in both credit-bearing classwork as well as non-transferrable, developmental classes. Supplemental Instruction originated in order to help students who were in professional school. Over the past thirty plus years, use of SI has expanded to include all types of classes from biology and chemistry to history and sociology. The main factor in providing SI as a resource is the class having a >30% D, F, W in class grades. Students in the Mathematics Workshop developed by Treisman and utilizing Supplemental Instruction, outperformed their counterparts in calculus and were retained in the class, while almost 50% of the students not in the Math Workshop did not pass (Treisman, 1983). SI was studied in a biology class at Wayne State University and was found to be effective even with students who had low ACT scores and low entrance GPA’s (Shaya, Petty & Petty (1993). The authors found that those students who attended SI had a mean score ½ point higher (2.9) than the students who did not attend SI (2.4). There was also a study conducted by Moore and LeDee (2006) who found that although there was no
significant difference in numerical mean grade between SI and non-SI participants there was a significant difference in grade distribution. SI students were more likely to receive more C’s and less A’s, D’s and F’s compared to non-SI users (p. 15). This may affirm the fact that many students who utilize SI would not have passed the class if SI had not been available. Blat et al. (2001) showed that while the mean course grade average between SI students and non-SI students did not increase, SI had a positive impact on the number of students passing the class. Students were more likely to stay in the class instead of withdrawing and more students passed the class. There was also a ten point gain in retention rate from sophomore year to junior year and an eight point gain from junior year to senior year when comparing SI students to non-SI students. (n.p.)

Similar studies conducted at San Francisco State University (SFSU) by Peterfreund, Rath, Xenos, and Bayliss (2007), at a large public Midwestern university (Hensen & Shelley, 2003), in organic chemistry by Lyle and Robinson (2003) as well as in math and chemistry by Parkinson (2009) showed that SI students in STEM classes had higher course GPA and fewer D’s and F’s than non-SI students within the same classes. The biggest difference was recorded among underrepresented minority students; the URM SI students not only surpassed the general students, but also the non-URM students utilizing Supplemental Instruction. For example, in the introduction to biology class, there was a .72 (significant) grade difference between URM SI students and URM non-SI students (Peterfreund, Rath, Xenos, & Bayliss, 2007, p. 500).

While most of the literature documents positive effects on student GPA in credit-bearing coursework when utilizing SI, there is some research that does not show any substantial difference in the mean GPA grades between SI and non-SI users (Blat et. al,
2001, Collins, 1982; Fest, 2000, Moore and LeDee, 2006). Fest studied a biology class using a quasi-experimental design. Half of the class received SI and the other half was the control group. The author used the $t$-test and ANOVA to study the data, which pointed to no difference in mean GPA scores between the experimental group (SI) and the control group ($p < .458$). They did however see an increase in GPA for the middle ability group as opposed to the high or low ability groups. The groups were prescribed by SAT and prior college GPA. One factor that may account for their results is how they used the control group. Although the author eliminated contaminating variables, and there was a control group who did not receive Supplemental Instruction, the control group still received review sessions during their biology discussion.

**Developmental Classes.** California has one of the largest community colleges systems in the United States. Only 16.4% of the state’s community college students in math, 28.0% in English and 38.3% in reading test into transfer/college-level course work (Basic Skills Accountability Report, 2009). In 2001, nearly 1/3 of all entering college students within the United States were required to take a remedial course in math, writing or reading (National Center for Education Statistics, 2003). Bettinger and Long (2008) looked at basic skills within the state of Ohio to determine whether students in general remediation persist to college-level course work. Their conclusion suggests that students who took the remediation course work had better educational outcomes as compared with those students who came from similar backgrounds and preparation, but who were not required to be in developmental coursework (p. 760). More important to this study dealing with STEM majors, Bettinger and Long’s results showed that taking math remediation increased the chances of degree completion for those who were previously
interested in a math or math-related field. This result was achieved by controlling certain demographics such as race, ACT composite score, and high school GPA. English remediation had the opposite effect in that fewer of those who needed English remediation, but who wanted to major in an English-related major, actually completed an English-related major.

Studies regarding developmental classes continue to show different results, but there is evidence that adding Supplemental Instruction to the mix might be beneficial for students in developmental classes. Originally, Arendale (cited in Wright, Wright, and Lamb, 2002) stated that SI is most effective when, “students need to integrate large volumes of lecture notes, textbooks, and outside readings. Many developmental education classes are primarily skill-based rather than processing large volumes of material” (p. 31). Most developmental math classes are not identified as appropriate courses to use SI because students in those classes usually do not have a good foundation of math concepts and need to learn basic skills. Wright et al. disagreed with Arendale’s suggestions and conducted their own study using SI in 90 developmental math courses. Wright et al. (2002) found that the developmental math classes were among the largest on campus, they had extremely low pass rates, they covered a large amount of material, and most were taught by adjunct faculty or graduate students who were not trained to work with under-prepared students. After two pilot projects, the SI model was institutionalized for all but one math class. The SI Leaders used a modified version of SI whereby the SI leader was an active participant in the classroom, but the rest of the sessions were considered traditional by the standards set by the University of Missouri Kansas City where SI was first developed. As was seen with credit-bearing SI classes at the
International Center for Supplemental Instruction located at the University of Missouri, the students had an average of one/half letter grade higher and there was a 14% increase in students passing the class if they were involved in SI (p.34).

Supplemental Instruction has been found to meet the challenges of students who are in developmental classes because it engages students through active learning, and students can contextualize the learning skills with direct course content. Wild and Ebbers (2002) looked at retention in community colleges and found that using supplemental instruction was one of four successful strategies for student retention. Higbee (2005) recommended that first-year students who need developmental coursework engage in active learning and the transfer of skills, two components of Supplemental Instruction. Boylan, Bonham, and White (1999) suggested that helping the student in remediation by focusing on development of metacognitive skills, another focus of SI, is a best practice in serving this population of students.

With such a high proportion of community college students having to take at least one developmental class, yet at the same time showing poor outcomes in transfer-level success, efforts to combat this lack of success are necessary to meet the demands of STEM-related jobs. Boggs (2010) stress the importance of helping students through the pipeline, stating that 50% of science and engineering baccalaureate students who graduated in 2000 enrolled at a community college at some point in their college career. For the reasons stated above I believe it was important to include in my study a college who delivered SI services to students taking developmental education coursework in STEM.
Impact of Supplemental Instruction and Course Sequencing

Studies indicate that SI is indeed effective in creating short-term success in both course and term GPA for students. Accounting for self-selection and college pre-entrance differences among students, many studies have shown a consistent increase in student’s GPA by ½ letter grade through the utilization of SI. What has not been studied is the use of SI and its effectiveness on course and overall GPA as students progress from one course to the next in a required sequence. Topics that come close to this study usually discuss the sequencing of developmental classes and class prerequisites. Hashford’s study completed in 2000 suggests that not all prerequisite courses prepared students to perform well in subsequent classes. They found variances depending on subject area and sequence of classes. They found that students who received higher grades in prerequisite classes performed better academically in the succeeding classes and those students who received a low passing grade (C) in the prerequisite had a more difficult time passing the subsequent class. This correlates with the research done by Hagedorn, Lester, and Cypers (2010) who studied community college students in math classes. Students who did well in low-level math classes such as pre-algebra and intermediate algebra had an increased rate of passing the higher-level classes including transfer level math.

The study showed that students who passed the class, but only with a grade of C, exhibited the same tendencies within subsequent classes as those students who did not pass the class. This suggests that passing a lower-level math class with a C does not adequately prepare the student for the next level math class. They also found that students with a C grade at the lower levels of math were less likely to attempt a transfer class and the percentage was even smaller than those students who did not pass the lower-level
math class. Because SI increases the amount of students passing with a better grade, utilizing SI not only helps with retention of students for the current class, but may also be a great asset as the students continue with the next level of courses within the sequence. The study reported in this dissertation looks at whether SI does increase persistence through the course sequence even when students receive a C in a lower-level course.

The question that remains is what occurs among students who take part in Supplemental Instruction in the first course of the sequence and then continue with SI either immediately after the initial course or sometime within the course sequence. Very little literature can be found regarding this area of study. Peterfreund et al. (2007) found that students who take SI enroll in subsequent classes within the subject area at higher rates than non-SI participants. For example, students who utilized SI in Introduction to Biology I enrolled in Introduction to Biology II at a rate 16% higher than non-SI participants. For Chemistry the increase was 22%. This increase was shown in later classes as well. Those who took General Chemistry I and then continued the sequence of General Chemistry II, Organic Chemistry 1, and Organic Chemistry II had a higher rate of enrollment in each of these subsequent classes as compared to non-SI participants. However, the study did not include any information on whether additional services were offered to students in the subsequent classes or if the students increased their overall GPA.

Ogden et al. (2003) looked at four groups of students to determine any long-term impact of Supplemental Instruction. The groups were broken into traditionally accepted (both SI and non-SI participants) and conditionally accepted (both SI and non-SI participants). The conditionally accepted were those students who were required to complete ESL requirements or Learning Support Program requirements in order to stay
enrolled at the university. The class used was a political science class at a four-year college and the students did not have any other SI intervention in subsequent classes throughout the two years.

Ogden et al.’s study found the conditional SI students had a higher mean course GPA and cumulative GPA than the conditional non-SI students and continued to have a higher cumulative GPA throughout the first three semesters after utilizing SI. The mean GPA of the conditional SI students dropped by the fourth semester, but was still higher than that attained by the conditional non-SI students. The traditional SI students started with higher mean GPA for the course and kept a higher mean GPA over any other group for the subsequent two years.

What is just as important is the fact that conditional SI students had a higher retention rate (88.3%) than the traditional SI students (65.3%). Ogden et al. suggested booster SI sessions to maintain the increase in mean cumulative GPA for the conditional SI students. This corresponds to this present study, which will consider if additional SI sessions in subsequent classes do in fact help students increase their course grade.

Gattis (2000) did, in fact, look at the effect of having SI classes in a course sequence of chemistry classes. Those students who attended SI sessions for both Organic Chemistry I and II received the highest grades when the students had taken previous SI sessions in Chemistry I and Chemistry II compared to just one semester of SI or no SI at all. The study did not test for any effects when students took SI sessions concurrently in one semester.
Summary

This literature review thematically covered potential differences in college GPA and retention of students particularly at community colleges. According to literature, Supplemental Instruction can increase course grade, overall GPA and student retention. Supplemental Instruction is founded on both cognitive and social constructivism and uses collaborative learning to enhance student learning through the use of study skills techniques, analysis and synthesis of class materials and group learning. Besides constructivism, the literature review also covered the theory of student development and how the social and academic development of students correlates to student retention. SI has been shown to better prepare the student both academically and socially, thus leading to student retention.

This literature review reveals that there are gaps in our knowledge regarding Supplemental Instruction and the use of SI in course sequencing. That is why this study will aid in the understanding of SI and how SI may be used more effectively at community colleges. This study will be able to suggest whether the use of SI in course sequencing has an impact on student course grade and persistence.
Chapter III
Methodology

This chapter will explain the methods used in identifying and capturing the data needed to answer three main research questions:

1A. Is there a difference in course grade between community college SI participants and non-participants in a STEM course and how does SI affect student grades within developmental coursework?

IB. Does participation in SI for a development-level STEM course have an effect on the grade in the subsequent course in the sequence?

2A. Is there a difference in course grade between community college students who utilize SI in a sequence of STEM courses as opposed to one course?

2B. Is there a difference in course grade between community college students who utilize SI in two courses within one semester as opposed to one course within a semester?

3. Is there a difference in successful persistence within a STEM course sequence when utilizing SI versus no SI?

Supplemental Instruction has been considered an effective practice by the U.S. Department of Education since the 1980’s. Significant research on SI outcomes at four-year universities shows an improvement in course grade by ½ letter grade or more (Belzer, 2003; Martin & Arendale, 1992; Parkinson, 2009; Peterfreund et al. 2007; Treisman, 1983). However, little is found within existing literature about the use of SI and its impact at community colleges. In addition, I have not found any study focusing on SI in a course sequence.
General Research Design

This study will be guided by a causal-comparative design, which entails using quantitative methods. Creswell (2008) describes quantitative research as, “…a type of educational research in which the researcher decides what to study, asks specific, narrow questions, collects quantifiable data from participants, analyzes these numbers using statistics, and conducts the inquiry in an unbiased, objective manner” (p. 46). Minimal research can be found on Supplemental Instruction and its effect on grade within a sequence of courses; therefore, using quantitative analysis to conduct this study is appropriate to answer the research questions. This study used secondary quantitative data and quantitative analysis to complete the study. A null hypothesis, which is defined as a non-relationship between variables, is used for quantitative analysis. “The null hypothesis acts as both a starting point and a benchmark against which the actual outcomes of the study can be measured” (Salkind, 2010, p. 164). The null hypotheses for this study are:

HØ1A: There is no significant difference in course grade between community college students who attend SI for one semester and students who do not attend SI at all during the semester.

HØ1B: Participation in SI for a development-level STEM course has no significant impact on the grade in the subsequent course in the sequence.

HØ2A: There is no significant difference in course grade between students who utilize SI in a sequence of STEM courses as opposed to one course.

HØ2B: There is no significant difference in course grade between students who utilize SI in two STEM courses within one semester as opposed to one course within a semester.
**HØ3:** There is no significant difference in successful persistence within a course sequence when utilizing SI versus no SI.

**Experimental Design and Validity**

There are several types of experimental designs within quantitative studies. This study will use the causal-comparative design, better known as the ex post facto investigation. Ex post facto research, “is a method of teasing out possible antecedents of events that have happened and cannot, therefore, be engineered or manipulated by the investigator” (Cohen, Manion, & Morrison, 2000, p. 201). This type of study observes any difference between two groups and then works in reverse to see if there is a causal relationship between the independent and dependent variables (Fraenkel & Wallen, 2000).

There are limitations to the ex post facto investigation that can be a threat to internal validity. Because this study could not manipulate the independent variable, there was a lack of control for any data that may have contained anomalies. An example of this type of threat would have been all students who attended SI also had a 4.0 GPA while in high school. There was a lack of randomization; the groups had already been decided before the study. For example, there was no control over who utilized SI in a particular math course.

A large concern for the causal-comparative design was whether the study was able to show cause and effect with the data presented. A third variable may have been the cause, yet this third variable was not a consideration of the study. To illustrate this point, I did not have any data on whether students who utilized SI also utilized tutoring. The tutoring could have been the reason for the difference in course grade as opposed to the utilization
of SI. Regression Analysis was conducted on the data because regression analysis separates the effects of the independent variable on the dependent variable to examine the unique contribution of each independent variable (Ceja, 2011). Although I did not have information regarding students and additional tutoring, regression analysis was able to flesh out the distinct effect of SI on course grade compared to the variables for which I did have data.

A final threat to internal validity is self-selection. By presenting students with an opportunity to receive better grades, those students who are motivated and who usually receive good grades might be more willing to spend extra hours per week to utilize Supplemental Instruction. Because SI is voluntary, self-selection may occur. Bowles and Jones (2000) and Gattis (2002) studied self-selection bias and its effects on SI. Both studies showed that controlling for motivation and good grades, students who used Supplemental Instruction services still increased course grade over those students who did not use SI.

**Student Population and Sampling.** The sample used for this study comes from two community colleges (Community College A and Community College B). Community College A lies on the fringe of a large urban area. According to the Integrated Postsecondary Education Data System (IPEDS), the college is considered a large suburban campus. There are several other community colleges as well as several private and four-year institutions within 30 miles of Community College A. The college has an enrollment of approximately 25,000 students who are 37% Hispanic, 17% African American, 15% Asian and 19% White Non-Hispanic. Its retention rate (fall to fall) for first-time students is 75% for full-time students and 43% for part-time students. Its three-
year graduation rate is 25% with a 10% transfer rate. There were twice as many students graduating with an A.A. degree as with an A.S. degree.

Most of the Supplemental Instruction classes for Community College A are provided by the math department and covers both developmental and credit-bearing courses. SI is provided at the most basic arithmetic level and continues through all its developmental classes. Intermediate algebra is sectioned for STEM and non-STEM majors with SI in each type of section. Credit-bearing classes are also divided among STEM, non-STEM, and elementary school teachers and SI is provided for all three types of credit-bearing coursework. Supplemental Instruction is offered through pre-calculus.

The college uses the “standard SI model” founded by Deanna Martin through the University of Missouri, Kansas City (UMKC). This standard model conducts SI sessions close to the time of each class. All SI Leaders are trained by SI trainers and the SI classes offered are strictly voluntary in nature. Community College A provides two sessions of SI per week for each SI-supported class, with each session covering a new topic or helping students learn a new study skill for the same topic. Students have the opportunity to attend a total of 30 SI sessions for each individual course. The SI sessions are arranged either before or after class lecture.

Community College B is considered an urban college according to Integrated Postsecondary Education Data System (IPEDS). Similar to Community College A, there are several other community colleges and four-year universities within 30 miles of Community College B. The college’s enrollment of 31,000 includes 51% Caucasian, 21% Latino, 2% African American, and 8% Asian students. Its fall-to-fall retention rate is 45% for full-time students and 45% for part-time students. The graduation rate is 28% with a
transfer rate of 16%. Similar to Community College A, Community College B uses the "standard SI model" and follows a similar workshop pattern of SI sessions starting in week one of the semester.

The selection of subjects used in this study was based on the sections of courses that provided Supplemental Instruction as a resource. Grades were divided and analyzed based on utilizing SI or not per semester. Both Blat et al. (2001) and Parkinson (2009) used the more stringent model of five SI sessions, yet Wolfe (1991) found no correlation between the number of sessions attended and course grade. I used the cut-off point of three or more sessions in order to remove those students who only used SI during midterms and finals, thus not learning the additional study skills offered at the sessions. I followed a group of students selected from each community college. Community College A’s selection (6194 students) came from students enrolling in STEM courses Fall 2008 and continuing until Fall 2011. Community College B’s selection of students (1534 students) enrolling in STEM courses went from Fall 2009 until Spring 2011.

All data collected were secondary data. Secondary data are data collected by someone else other than the researcher investigating the study. There are advantages and disadvantages to using secondary data. The advantages of using secondary data are that it is economical and it saves time as well as effort by the researcher (Fraenkel & Wallen, 2000). Secondary data avoid the potential data collection problems that can occur when seeking primary data such as the time and energy needed to collect primary data. Using secondary data also provides a basis for comparison without researcher bias (Cho, n.d.). Unfortunately, secondary data may not include the data necessary to completely answer research questions such as demographics or entry GPA. Other issues with the use of
secondary data can be: the detail of data availability, lack of control by the researcher regarding the quality of data, or data may be outdated.

According to the Management Study Guide (2009), four requirements should be satisfied in order for secondary data to be relevant:

1. Availability of the exact type of data the researcher is requesting--I wanted to study if there were any socio-economic differences within students who utilized SI, but I was not able to obtain these data. I was however able to obtain course grades for students; thus my research questions were directly related to the data I obtained from the community colleges.

2. The units of measure from secondary data should match what the study proposes--My research questions were based on course grades from community colleges, rather than term or cumulative GPA, because course grades were the only data I was able to obtain.

3. Accuracy of the data--I obtained data from the community colleges, and as such, I assumed the data provided to me were accurate. I could not confirm that accuracy such as in data input, instructor input of data into the database, or even grades for students were accurate.

4. Availability of adequate data--In obtaining the data, I requested the most recent of data from each community college and that the data fit my protocol, i.e., developmental course work and college coursework where students utilized SI in their course work. Each community college had an adequate number of students within the data to complete my data analysis.
Student information regarding courses taken, course grades and SI sessions were retrieved from the Institutional Research Office at both colleges.

**Course Sequence.** The study looked at the effect of SI when students utilized this service for one or more courses within a mandated course sequence. Community colleges require placement tests in math and the student is placed at certain levels based on the results of these placement tests. A student can be placed anywhere within the spectrum of courses from the lowest math course (usually pre-algebra, but can be as low as arithmetic) to college-level coursework such as pre-calculus. In addition, each department sets prerequisites for courses. For example, a student cannot register for Biology 102 without successfully completing Biology 101. Community College A offers pre-college level math and college-level math, as shown in Figure 3.1. The course sequence for Community College B is shown in Figure 3.2. Although Community College B also offers pre-college level math, the specific data they provided for this study were only from college-level classes.

![Course Sequence Diagram]

*Figure 3.1. Math Courses at Community College A*
Variables. SI was the independent variable in this study. Students were considered to have taken SI for a particular course if they attended three or more sessions of SI associated with that course. Students who took fewer than three sessions were considered not to have utilized SI for a course. Course grade and successful persistence were the dependent variables for this study. Research Question 1A observed any differences in course grade for these two groups of students. The course grades were disaggregated into developmental and college-level coursework for Community College A and different subject areas for Community College B. Research Question 1B looked at the impact SI had from the previous course on final course grade for the next consecutive course in developmental math. Research Question 2A considered the course grade when students utilized SI for just the first course in a course sequence during consecutive semesters compared to students who utilized SI for two courses during consecutive semesters. Research Question 2B considered course grade when students utilized SI for two courses within a semester. The analysis was completed for the second of the two
courses in the sequence. Research Question 3 observed differences in successful persistence, (C or better in first course and C or better in second course) when students utilized SI.

**Data Collection.** After approval from the Institutional Research Board of both California State University Northridge and the community colleges, a list of variables and their corresponding data were requested from the Institutional Research Office of each community college. Names from attendance records of SI sessions were matched with course registration as well as course grade. Identifying data were stripped and the information sent via an Excel spreadsheet. A stand-alone computer in the office and my personal laptop that was not linked to any other computer via a modem was used to perform all statistical analysis. Both computers were locked with a password when not in use. All data will be deleted and destroyed seven years after the publication of this dissertation.

Each college’s data were sent differently to me. Both colleges sent data based on student records, but Community College A sent its data showing one row per student. The columns were grouped based on term and each row had a unique student record. This is considered a wide format in SPSS. Community College B sent its data based on cases, or the long format. For this study, cases are comprised of only one course per student. The data, as seen below in Table 3.1 can show one student having several cases. There were only four columns of data for Community College B: term, course, grade and SI sessions.
Table 3.1

Wide Format and Long Format

<table>
<thead>
<tr>
<th>Wide Format</th>
<th>Community College A</th>
</tr>
</thead>
<tbody>
<tr>
<td>StudentID</td>
<td>FA08 Course</td>
</tr>
<tr>
<td>1</td>
<td>Math 12</td>
</tr>
<tr>
<td>2</td>
<td>Math 73</td>
</tr>
<tr>
<td>3</td>
<td>Math 40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Long Format (Cases)</th>
<th>Community College B</th>
</tr>
</thead>
<tbody>
<tr>
<td>StudentID</td>
<td>TERM</td>
</tr>
<tr>
<td>1</td>
<td>F2009</td>
</tr>
<tr>
<td>2</td>
<td>F2011</td>
</tr>
<tr>
<td>2</td>
<td>F2011</td>
</tr>
<tr>
<td>3</td>
<td>F2010</td>
</tr>
<tr>
<td>3</td>
<td>S2011</td>
</tr>
</tbody>
</table>

**Data Analysis.** The data were then analyzed through statistical software, *Statistical Package for the Social Sciences 20* (SPSS). Because both sets of data were not in similar formats, both sets of data needed to be converted from Excel into a useable form in SPSS. Community College A had to be restructured from variables into cases in order to retrieve information as a group of semesters rather than individual semesters. This allowed for the merging of data across semesters. Community College B’s data were restructured from cases into separate semesters in order to cross-tabulate grades with the number of SI sessions.

While the general design of this study used the ex post facto investigation, a correlation analysis was also conducted on the data. “Correlational Research describes the degree to which two or more quantitative variables are related and it does so by the use of a correlation coefficient” (Fraenkel & Warren, 2000, p. 359). In other words,
correlational studies help us to see the relationship, if any, between the independent and dependent variables. To answer the question if one variable has a relationship with another variable, correlational analysis uses two descriptions: direction and magnitude. The direction refers to the variables being directly or indirectly related, and magnitude refers to how much the variables are in relation to each other. Pearson created a correlation coefficient that reflects the numerical index of the relationship (Salkind, 2010). The range goes from -1 to +1. A coefficient closer to 0 defines a weak relationship whereas the absolute value of the coefficient is the magnitude of the relationship. The +/- describes the direction of the relationship.

Linear regression was used to better define or explain the relationships between the dependent and independent variable. Whereas the correlation explains if there is a relationship between the two variables, linear regression will predict one variable (predictor variable or independent variable) based on the criterion variable or dependent variable. Using the coefficient of multiple correlations ($r$), a measure of strength between the predictor and criterion variable can be seen. The $r$-value will be higher when there is a strong prediction between the two variables. To go one step further, taking the square of the coefficient of multiple correlations ($r^2$), called the coefficient of determination, allows the researcher to determine the variance of the dependent variable accounted for by the multiple independent variables. In other words, a higher $r^2$ indicates that the independent variables account for a greater percentage of variance within the dependent variables.

Logistic regression was used for Research Question 3. Logistic regression is used instead of linear regression when the output variable is discrete (non-continuous). I used
the dichotomous variables for both the dependent and independent variables, which leads to using logistic regression.

Once the data were restructured into both forms (variables and cases) for both colleges, the next step was to transform some of the data into new variables. Course grades for each semester were transformed from letter grades to number grades that corresponded to the norm for the grade such A= 4, B= 3 etc. Withdrawals were considered as “system missing” in SPSS and were not included in part of the analysis. The grades were then transformed again into a dichotomous variable with 1 representing A, B, C grades and 0 representing all other grades. Supplemental Instruction was also transformed into dichotomous variables; attendance at three or more sessions in a semester was coded as 1 and fewer than three sessions were coded as 0. All recoded variables were labeled new variables in order to retain the original variables and their content.

**Institutional Demographics.** Community College A’s data included 6194 students who took at least one math class during fall semester of 2008. All of these students were taking developmental math in fall 2008. The data provided all subsequent math classes this initial group of students took through spring 2011 as well as course grades and the number of SI sessions for each semester. Although the data also included course and grade during the summer sessions, these data were not directly used to answer Research Questions 1 and 2 as there was no SI available to students in the summer. The summer courses and their grades, however, were used to look at successful persistence within the sequence of math courses. Community College B’s data consisted of 1534 students from
fall 2009 through spring 2011. These students were taking math, biology and/or physics, all college-level classes.

**Correlation.** Before examining my research questions, it was important to establish whether even single semesters of SI had an impact on course grade in my sample, as prior studies had found. If there were no relationship between SI and course grade, continuing with my study would have been futile. To establish this relationship, I conducted a basic correlation analysis, which indicates the extent of the relationship between two variables. Each college’s data were tested using the full sample and then disaggregated into select cases, such as just the grades for biology or developmental math, to see if there was a stronger correlation within a sub-population. The Spearman’s rho test of analysis was used because the data were ordinal data.

**Research Question 1A.** Is there a difference in course grade between community college SI participants and non-participants in a STEM course? Although the same analyses were conducted for each college, because of the difference in how the data were collected for each student and how each student was tracked throughout consequent semesters, each college was analyzed separately.

**Comparison of Means.** To answer the first part of research question I conducted, for each college, a comparison of means between course grade of those students who used or did not use SI each semester. I analyzed the data by using the comparison of means test with all grades from all courses that had SI as a support service in math for Community College A and for calculus, biology, and physics for Community College B. I then disaggregated the data into subsets: developmental math and college-level math for
Community College A and biology, physics, and calculus for Community College B. The analysis of the subsets was for all semesters combined.

Independent Samples t-Test. To test whether the means were statically different from each other, an independent samples t-test was used for each set of data. This test assumes that the data used will be normally distributed and that there is equal variance on the dependent variable (Archambault, 2000). To validate the assumptions for a t-test, the Levene’s Test for Equality of Variance was used to test whether there was equal variance on the dependent variable. When the Levene’s Test revealed that the data for the dependent variable were not normally distributed, I performed a Mann-Whitney U-Test. This method tests any significance between the means of the two groups without the need for normal distribution of variance (MacFarland, 1998).

Research Question 1B. Further analysis was completed for Community College A because all students started in developmental math but some students continued their math course-taking to at least one college-level math course. Linear regression was utilized to see if Supplemental Instruction in the developmental courses had any effect on the grade at the next level and especially from the highest level of developmental math to the college level math. For example, the formula for linear regression on the dependent variable, the second level of developmental math and three levels below college-level math is: \[ \sum_{dm2grade} = b_0 + b_1DM1Grade + b_2DM1SI_2 + b_3DM1SI_3 + b_4DM2SI_2 + b_5dm2SI_3 + e. \] DM2grade is the grade received in the second to the lowest developmental math course. DM1SI_2 represents the students who did not use SI (defined as attending two or fewer sessions). DM1SI_3 represents the students who attended SI sessions for the lowest developmental course (defined as attending three or
more times). A similar formula was used with similar predictor variables for each regression analysis to see if there was any effect for those going from the highest level of developmental math to the first level of college math. An ANOVA was completed for each regression to ensure a good fit for the analysis.

**Research Question 2A.** Is there a difference in course grade between community college students who utilize SI in a sequence of STEM courses as opposed to one course? The independent t-test was used to answer this research question for both community colleges. First, the data were filtered by selecting students who took classes in the first and second semester, then second and third semester, etc. The original recoded SI sessions were then analyzed with students who utilized SI in fall ‘08 and spring ‘09, versus SI used in fall ‘08, but not in spring ‘09. The second semester course grade for each two-semester sequence was analyzed to establish if there was any significance in final course grade. For the purpose of semester sequence, any duplicates (those students that took two classes within one semester) were filtered out to keep the results as clean as possible. A Mann-Whitney Test was used because the Levene’s Test for Equality of Variances showed the course grades were not normally distributed.

**Research Question 2B.** An additional step was needed for Community College B to account for the fact that students had the opportunity to take more than one course utilizing SI within a semester. The data were recoded into duplicates = 1 and non-duplicates = 0. The STEM course grades of students who took two STEM courses in one semester and who utilized SI in both STEM courses were compared to the STEM course grades of students who took two STEM courses in a semester, but only utilized SI in one of the STEM courses. An independent samples t-test was used as the statistical test to see
if there was any significant impact on grades. All semesters were aggregated to find the mean. The process was completed again after disaggregating the data into separate semesters and mean grades were calculated based on each semester.

**Research Question 3.** Is there a difference in successful persistence within a STEM course sequence when utilizing Supplemental Instruction versus no SI? The grades for each semester were recoded into dichotomous variables. Those receiving an A, B, or C were coded as “1” and those who received anything else including a W were coded as “0”. The SI variable used was also dichotomous, with three or more SI sessions as the cut-off point. A Crosstab analysis with a Chi-Square Test was completed to provide the data to answer this question. An independent samples t-test was used when looking at the overall data to see if there was an impact on successful persistence. The data were then analyzed using a sequential course sequence such as fall ‘08-spring ’09, spring ’09-fall ’09, etc. The data were coded as to the appropriate course sequence such as a student persisting (A, B, C grade) in Biology 101 and Biology 102. Only those students who took courses for each semester were analyzed. Students who did not take sequential coursework in the semester immediately following the original semester were deleted from this analysis. A logistic regression was performed to test if the model was a good fit. The model based on Hosmer and Lemeshow Test was found to be a good fit for the semester sequences.

**Validity and Limitations.**

As in the ex post facto investigation, there are threats to internal validity with correlation studies. Creswell (2008) proposes several threats within each category and these threats are discussed based on the present study. History refers to the potential of
another factor that is not related to the study altering the results of the data. An example would be if there were additional services for students other than Supplemental Instruction. There may be no difference in measured outcomes between those subjects who used SI versus who did not utilize SI. This would not necessarily mean that Supplemental Instruction was not beneficial; students who did not utilize SI could have possibly learned the skills to do well using other support services thereby receiving a good grade. All of the data were secondary data and there was not any experimentation during the study. There was no random assignment of subjects, thus the study was a quasi-experimental design.

The study may have more external threats than internal threats. Diffusion of treatment is one of the external threats. It is impossible to know if any of the subjects who did and did not do SI shared information with each other during the duration of the course. A second type of external threat is interaction of setting and treatment. Will the results be the same if the same study is conducted at a different college, such as a four-year institution or at a community college that has a STEM Center specifically for Supplemental Instruction? The degree to which the SI Leaders have been trained according to the curriculum developed by the International Center for Supplemental Instruction is another external factor. Some trainings at community colleges do not employ all of the potential learning skills of SI, thus students may not receive valuable information and resources to aid them in their coursework. Another external threat is the SI Leader’s years of experience in leading the group. Someone who is trained but does not have the experience of being an SI leader may not be as capable as someone with training and years of experience.
Not only must this study consider threats to internal and external validity, but as with every study, there are limitations. The first one has already been mentioned, that of not being able to control for students who may have employed other forms of services such as tutoring or SI in another department. I also wanted to study the impact of SI on term GPA, but only one of the colleges provided me with term GPA. Because I did not have data on when students started and completed college, I did not try to analyze this data. Given that this is an ex post facto investigation, the study has little say on the variables that can be used. Any variable/data for the study must be available through the Admissions Office and/or the Institutional Research Office. I wanted to study the race/ethnicity and gender as possible variables, but was not granted access to the data.
Chapter IV

Data Analysis

The purpose of this study was to see if there was any difference on course grade when students utilized Supplemental Instruction (SI) for more than one semester or within a semester. It has been shown that students who utilize SI receive higher course grades and have fewer D, F and withdrawals. My hypothesis was that when students utilized SI for two consecutive courses or for two courses within a semester, their course grades would be higher than students who only utilized SI for one semester or who only utilized SI for one course during the semester.

Review of Research Questions

It is important to review the research questions set forth in the first chapter of this dissertation. This study tries to answer these questions:

1A. Is there a difference in course grade between community college SI participants and non-participants in a STEM course and how does SI affect student grades within developmental coursework?

1B. Does participation in SI for a development-level STEM course have an effect on the grade in the subsequent course in the sequence?

2A. Is there a difference in course grade between community college students who utilize SI in a sequence of STEM courses as opposed to one course?

2B. Is there a difference in course grade between community college students who utilize SI in two STEM courses within one semester as opposed to one course within a semester?
3. Is there a difference in successful persistence within a STEM course sequence when utilizing SI versus no SI?

These questions are significant because only a small amount of literature focuses on SI and community colleges, with a decrease when STEM is included in any study. Although there is some literature such as Blanc, Debuhr, and Martin’s (1983), Peacock (2008) and Jarrett and Harris (2009) that contribute to the understanding of SI and its direct effect on student persistence, there is no literature which studies any sequence of courses to see if there is an additive effect when SI is utilized in two or more courses.

**Correlation of Supplemental Instruction and Course Grades**

One of the basic analyses that were completed for this data was correlation. This type of analysis indicated the extent of the relationship between supplemental instruction and course grades. I originally conducted the correlation analysis using STEM grades and whether students utilized SI or not in the STEM course. For Community College A, the grades were all math grades, both developmental and college level grades. The overall grades at Community College A had a weak but significant correlation, \( \rho(15,225) = 0.070, p < .001, \) two-tailed. I used the calculus, biology and physics grades for Community College B. The overall grades at Community College B had a higher correlation with \( \rho(2,863) = 0.238, p < .001, \) two-tailed, also showing significance. Correlations were then analyzed for developmental and college-level math in the case of Community College A and for the separate classes with Community College B.

The results found in Table 4.1 show that there was a connection, albeit a weak connection, between students’ grades and the use of Supplemental Instruction. Anything under 0.3 on the Spearman’s Coefficient Scale is considered a weak correlation between two variables.
Table 4.1

Correlation of SI and Course Grade

<table>
<thead>
<tr>
<th>Class Disaggregation</th>
<th>Correlation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CC A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dev. Classes</td>
<td>0.074</td>
<td>.000*</td>
</tr>
<tr>
<td>College-Level Classes</td>
<td>0.055</td>
<td>.003*</td>
</tr>
<tr>
<td><strong>CC B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>0.232</td>
<td>.000*</td>
</tr>
<tr>
<td>Math</td>
<td>0.170</td>
<td>.000*</td>
</tr>
<tr>
<td>Physics</td>
<td>0.350</td>
<td>.000*</td>
</tr>
</tbody>
</table>

* = Differences are determined to be significant at p-value of < .05;
CCA = Community College A; CC B = Community College B

Comparison of Means

To answer the first research question, do students who utilize Supplemental Instruction have a higher course grade versus students who do not utilize SI; I conducted a comparison of means between the course grade of those students who utilized SI and those who did not use SI. My null hypothesis was there was no significant difference between the mean of STEM course grades for courses in which students utilized SI for that course versus the mean in STEM course grades for courses in which students did not utilize SI for the course. In other words an individual student who took STEM courses both with and without SI contributed course grades to both means.

These comparisons were based on six semesters for Community College A and four semesters for Community College B. The comparison of means results are found in Figure 4.1.
Once again, the groups were further disaggregated to compare the course grade with those students who utilized SI versus students who did not utilize SI within the courses. All groups showed a higher course grade for those utilizing SI. Table 4.2 and Figure 4.2 displays the results of this analysis.

Table 4.2
Mean Course Grade for SI Users versus Non-SI Users

<table>
<thead>
<tr>
<th>Class</th>
<th>n</th>
<th>Mean Grade With SI</th>
<th>Mean Grade Without SI</th>
<th>P-Value(Anova)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CC A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dev. Classes</td>
<td>12,267</td>
<td>1.84</td>
<td>1.29</td>
<td>.000*</td>
</tr>
<tr>
<td>CL Classes</td>
<td>2927</td>
<td>1.98</td>
<td>1.51</td>
<td>.004*</td>
</tr>
<tr>
<td><strong>CC B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>572</td>
<td>2.47</td>
<td>1.68</td>
<td>.000*</td>
</tr>
<tr>
<td>Math</td>
<td>1885</td>
<td>2.42</td>
<td>1.64</td>
<td>.000*</td>
</tr>
<tr>
<td>Physics</td>
<td>394</td>
<td>2.59</td>
<td>1.38</td>
<td>.000*</td>
</tr>
</tbody>
</table>

* = Differences are determined to be significant at p-value of < .05.

Figure 4.1. Course Grades vs SI and No SI.
Significance of Means

I conducted the Levene’s Test for both community colleges using a dichotomous variable of grades A, B, and C as 1 and all other grades including withdrawals as 0. There were noteworthy differences between variances and the results were significant. Similar to the comparison of means, I calculated the mean of STEM course grades for courses in which students utilized SI for that course versus the mean in STEM course grades for courses in which students did not utilize SI for the course. On average, students who utilized SI had better STEM course grades than students who did not utilize SI for Community College A [$\alpha = 95\%$ confidence level, $t(527.424) = 8.840; p < 0.001$] and Community College B [$\alpha = 95\%$ confidence level, $t(1096.758) = 13.646; p < 0.001$].

Because there was not an equal distribution between the groups, a Mann-Whitney U-Test was conducted on the variables to test if the mean grade between SI users and non-SI users was statistically different. This test produces a $z$-score, which is another way to compare the means of two independent groups.
to denote whether the result is significant. The absolute value of $z$ must be greater than the significance level that was used for the test. Since I am using the significance level of $< 0.05$, the $z$-score must be equal or greater to the absolute value of 1.96 (Sheskin, 1997).

Results from both community colleges showed a significant difference between students who utilized SI and students who did not use SI during the course. [Community College A ($z = -8.670; p < 0.001$)][Community College B ($z = -12.708; p < 0.001$)].

An independent samples $t$-test was used for each course subject. Community College B was disaggregated into the three subject areas of math, biology, and physics. Although the data from Community College A only included data on math classes, the classes were disaggregated into developmental math and college-level math. Table 4.3 shows the results from disaggregating each community college into more specific areas and their statistical difference, if any.

Table 4.3

<table>
<thead>
<tr>
<th>Type of Course</th>
<th>Community College A</th>
<th>Community College B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Developmental Math</td>
<td>College-Level Math</td>
</tr>
<tr>
<td>Mean Grade with SI</td>
<td>1.82</td>
<td>2.42</td>
</tr>
<tr>
<td>Mean Grade without SI</td>
<td>1.29</td>
<td>1.64</td>
</tr>
<tr>
<td>Levene's Test of Significance</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Significance Value</td>
<td>.000*</td>
<td>.000*</td>
</tr>
<tr>
<td>Mann-Whitney Test Z Value</td>
<td>-8.252</td>
<td>-7.338</td>
</tr>
</tbody>
</table>

* = Differences are determined to be significant at $p$-value of $< .05$; Mann-Whitney Analysis was not needed for analysis of Biology coursework because the Levene Test was not significant.
The null hypothesis for Research Question 1 was not accepted. There was a positive impact of student course grade between the students who used SI and those students who did not utilize SI within a semester.

The Significance of Course Grade between Developmental Courses and Going from Developmental to College-Level Coursework.

Research Question 1B asks if SI utilized in a previous developmental course has any impact on the next course grade. Community College A offers developmental classes from arithmetic (four levels below college-level coursework) up to intermediate algebra (one level below college-level coursework). Linear regression was used to observe any effect of SI when students go from one developmental course to the next. The linear regression analysis points to the greatest effect coming from the previous course grade. The correlation was low and the predictor variables were not significant other than the previous course grade. The results are found in Table 4.4. The null hypothesis was accepted for Research Question 1B for students who went from one developmental course to the next level of developmental math.
Table 4.4

Linear Regression of Community College A in Determining the Effect of Predictor Variables

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Predictor Variables</th>
<th>β Value</th>
<th>Sig.</th>
<th>R² Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM2 Math</td>
<td>DM1 Grade</td>
<td>.471</td>
<td>.002*</td>
<td>.239</td>
</tr>
<tr>
<td></td>
<td>DM1_2</td>
<td>.109</td>
<td>.431</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM1_3</td>
<td>-.033</td>
<td>.807</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM2_2</td>
<td>.071</td>
<td>.603</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM2_3</td>
<td>.060</td>
<td>.665</td>
<td></td>
</tr>
<tr>
<td>DM3 Math</td>
<td>DM2 Grade</td>
<td>.356</td>
<td>&lt; .001*</td>
<td>.129</td>
</tr>
<tr>
<td></td>
<td>DM2_2</td>
<td>-.016</td>
<td>.804</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM2_3</td>
<td>-.026</td>
<td>.694</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM3_2</td>
<td>-.059</td>
<td>.365</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM3_3</td>
<td>.052</td>
<td>.420</td>
<td></td>
</tr>
<tr>
<td>DM4 Math</td>
<td>DM3 Grade</td>
<td>.417</td>
<td>.000*</td>
<td>.170</td>
</tr>
<tr>
<td></td>
<td>DM3_2</td>
<td>.026</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM3_3</td>
<td>.014</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM4_2</td>
<td>-.019</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM4_3</td>
<td>.054</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CL1 Math</td>
<td>DM4 Grade</td>
<td>.366</td>
<td>&lt; .001*</td>
<td>.133</td>
</tr>
<tr>
<td></td>
<td>DM4_2</td>
<td>.058</td>
<td>.101</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DM4_3</td>
<td>.019</td>
<td>.609</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CL1_2</td>
<td>-.052</td>
<td>.141</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CL1_3</td>
<td>-.086</td>
<td>.025*</td>
<td></td>
</tr>
</tbody>
</table>

Note. * = Differences are determined to be significant at p-value of < .05; DM = Developmental Math, DM1 is the lowest math class available, DM1_2 = those students who took one or two SI sessions, DM1_3 = those students who took SI ≥ 3 times within a semester.

Supplemental Instruction Taken in Subsequent Courses

The independent samples t-test was used to answer the next research question: whether there is an effect on students who take two semesters utilizing SI versus students who only utilize SI for one semester. The null hypothesis was that students who utilized two semesters of Supplemental Instruction would not have a better course grade for the second course taken in the sequence of semesters than students who utilized SI for only
the first of the two-semester sequence. My variables were course grades for the second class of each of the two-semester sequence and SI taken ≥ 3 times per semester.

For Community College A, there was a significant difference in the second semester grade for those students who utilized SI two consecutive semesters (M = 2.24, SD = 1.01632), \( t(44) = 14.785, p = .000 \) and those students who only utilized SI for one course within a sequence of terms (M = 1.49, SD = 1.35926), \( t(193) = 15.251, p = .000 \). The data had to be treated differently for Community College B due to the fact that all coursework was at college-level and students had the opportunity to take more than one course utilizing SI within a semester. For the purpose of this research question, the independent samples \( t \)-test was used, but any duplicates (those students that utilized SI in two classes within one semester) were removed to keep the results as clean as possible. Overall, there was a significant difference in the mean grades for those students who utilized SI two consecutive semesters (M = 2.91, SD = 1.13066), \( t(53) = 18.729, p < .001 \) and those students who only utilized SI for the first course within a sequence of terms (M = 2.43, SD = 1.22684), \( t(101) = 19.911, p < .001 \). The second term was used to compare the means. Results are found in Figure 4.3. The null hypothesis for Research Question 2 was rejected. There was a significant difference in STEM course grade for the second semester between students who took STEM courses for two consecutive-semesters utilizing SI versus students who only utilized SI in their STEM course for one semester.
The information was disaggregated to look at individual pairs of semesters. Only the developmental-level courses were used since there were not enough data to do any analysis on just the college-level courses. The results showed that mean STEM course grade for the second of the two terms was higher when students utilized SI for two STEM courses than for just one, but only one two-semester sequence was significant at > .05, that of Fall ‘10 to Spring ‘11. Spring ‘09 to Fall ‘10 did show significance at the 0.10 level. Results can be found in Table 4.5.
Once again, the independent samples t-test was used for comparison of students within each semester sequence for Community College B. The courses were all college-level courses within STEM. The data were filtered to capture only those students who took SI the first semester of the sequence and were then compared with the second semester. As with Community College A, Community College B’s mean course grade was higher when students utilized SI for two semesters, but only one two-semester sequence, from Fall ‘10 to Spring ‘11, was significant at p < .05. Spring ‘10 to Fall ‘11 was significant at the .10 level. The results can be found in Table 4.6.
Table 4.6

Two-Semester Comparison of Mean Grade

<table>
<thead>
<tr>
<th></th>
<th>Mean GPA</th>
<th>Levene’s Test for Equality</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI in Fall ‘09 and Spring ‘10</td>
<td>2.89</td>
<td>.295</td>
<td>.553</td>
</tr>
<tr>
<td>SI in Fall ‘09 but not Spring ‘10</td>
<td>2.71</td>
<td>.295</td>
<td>.553</td>
</tr>
<tr>
<td>SI in Spring ‘10 and Fall ‘10</td>
<td>2.57</td>
<td>.421</td>
<td>.085**</td>
</tr>
<tr>
<td>SI in Spring ‘10, but not Fall ‘10</td>
<td>2.54</td>
<td>.421</td>
<td>.085**</td>
</tr>
<tr>
<td>SI in Fall ‘10 and Spring ‘11</td>
<td>3.10</td>
<td>.436</td>
<td>* .017</td>
</tr>
<tr>
<td>SI in Fall ‘10, but not Spring ‘11</td>
<td>2.22</td>
<td>.436</td>
<td>* .017</td>
</tr>
</tbody>
</table>

Note. * = Differences are determined to be significant at p-value of < .05.
** significant at 0.10 level

Supplemental Instruction in Two Classes within the Same Semester.

The impact of utilizing SI in two courses within the same semester was only examined for Community College B, because the data set from Community College A did not include this information. The null hypothesis was that course grade for students who took two or more STEM courses within one semester and utilized Supplemental Instruction in both STEM courses would not be significantly different from STEM course grades for students who took two STEM courses, but only utilized Supplemental Instruction in one of the courses. The variables, once again, were an average of STEM course grades and SI versus no SI attended per course. An independent samples $t$-test was used as the statistical test to see if there was any significant impact on grades of those students who chose to utilize SI in two STEM classes within one semester versus students who only utilized SI for one of their STEM classes within a semester. There was a difference in the mean grade for courses within the semester for students who utilized SI
in both courses within a semester (M = 2.53, SD = 1.31486) versus students who only utilized SI for one of the two courses within a semester (M = 1.68, SD = 1.51326), t (571) = 6.647, p = .000. Because there was not equal variance, a Mann-Whitney Test was also performed and the z-value was -5.991. The null hypothesis was rejected. This effect was consistent across semesters. The mean grade was higher when students utilized SI in two STEM classes within the same semester versus students who only utilized SI in one of the two STEM classes. The results are found within Table 4. 7.

Table 4. 7

SI Utilized in Two Courses Within One Semester

<table>
<thead>
<tr>
<th>Two Courses in One Semester</th>
<th>Semester</th>
<th>Mean Course Grade</th>
<th>Significance of Equal Variance</th>
<th>P-value</th>
<th>Mann-Whitney Test Z-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Courses with SI</td>
<td>Fall 2009</td>
<td>2.62</td>
<td>.040</td>
<td></td>
<td>-3.094*</td>
</tr>
<tr>
<td>One Course with SI</td>
<td></td>
<td>1.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Courses with SI</td>
<td>Spring 2010</td>
<td>2.67</td>
<td>.048</td>
<td></td>
<td>-3.003*</td>
</tr>
<tr>
<td>One Course with SI</td>
<td></td>
<td>1.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Courses with SI</td>
<td>Fall 2010</td>
<td>2.38</td>
<td>.170</td>
<td>.001*</td>
<td>-2.641*</td>
</tr>
<tr>
<td>One Course with SI</td>
<td></td>
<td>1.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Courses with SI</td>
<td>Spring 2011</td>
<td>2.42</td>
<td>.001</td>
<td></td>
<td>-2.641*</td>
</tr>
<tr>
<td>One Course with SI</td>
<td></td>
<td>1.60</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. * = Differences are determined to be significant at p-value of < .05. or z-value is greater than absolute value of 1.96
Supplemental Instruction and Persistence

The last research question is do students who utilize Supplemental Instruction successfully persist through a course sequence at a greater rate those students who did not use SI as a support service? Successful Persistence was defined as receiving an A, B, or C in a STEM course and then continuing on to a higher level course the following semester and also receiving an A, B, or C in the second STEM course within the same subject area. The null hypothesis was there was no significant impact in persistence when Supplemental Instruction is utilized by students for a two-semester sequence.

Persistence within Community College A. Overall, students who utilized SI at Community College A successfully persisted at a rate of 74.3% compared to 54.6% ($X^2$ = 49.103, df = 1, $p < .001$). The results are illustrated in Figure 4.4. The t-test results showed a mean grade of .7430 ($1 = A, B, or C$) compared to .5462 for students who did not use SI (Mann-Whitney $Z$-Test = -7.005, $p < .001$).

![Figure 4.4. Successful Persistence](image-url)
The null hypothesis for Community College A (as well as Community College B) was rejected. When disaggregated into semester sequence (Table 4.8), Community College A showed a higher persistence rate among students who utilized Supplemental Instruction versus no SI, but only the Fall ‘08-Spring ‘09 and Fall ’09-Spring ’10 sequences showed any significance.

Table 4.8

Community College A Persistence Rate Between a Two-Semester Sequence

<table>
<thead>
<tr>
<th>Consecutive-Semester Pairs</th>
<th>Persisted through Sequence Using SI (in %)</th>
<th>Persisted through Sequence Not Using SI (in %)</th>
<th>Chi-Square P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall ‘08-Spring ‘09</td>
<td>51.3</td>
<td>31.9</td>
<td>.000*</td>
</tr>
<tr>
<td>Spring ‘09-Fall ‘09</td>
<td>30.0</td>
<td>25.3</td>
<td>.344</td>
</tr>
<tr>
<td>Fall ‘09–Spring ‘10</td>
<td>35.1</td>
<td>22.4</td>
<td>.028*</td>
</tr>
<tr>
<td>Spring ‘10-Fall ‘10</td>
<td>36.4</td>
<td>22.7</td>
<td>.072</td>
</tr>
<tr>
<td>Fall ‘10-Spring ‘11</td>
<td>40.9</td>
<td>23.7</td>
<td>.067</td>
</tr>
</tbody>
</table>

Note. * = Differences are determined to be significant at p-value of < .05.

A logistic regression, with results in Table 4.9, was performed to test if the model was a good fit. The model based on Hosmer and Lemeshow Test was a good fit for the semester sequences. Only the Fall ‘09-Spring ‘10 semester sequence showed significance for the predictor variable of SI.
Table 4.9

Logistic Regression Using Course Grade and SI as Variables

<table>
<thead>
<tr>
<th>Variable Analysis</th>
<th>Fall '08-Spring '09</th>
<th>Spring '09-Fall '09</th>
<th>Fall '09-Spring '10</th>
<th>Spring '10-Fall '10</th>
<th>Fall '10-Spring '11</th>
</tr>
</thead>
<tbody>
<tr>
<td>B for SI</td>
<td>0.371</td>
<td>0.118</td>
<td>0.579</td>
<td>0.200</td>
<td>0.784</td>
</tr>
<tr>
<td>t-value for SI</td>
<td>1.46</td>
<td>0.51</td>
<td>2.09</td>
<td>0.55</td>
<td>1.72</td>
</tr>
<tr>
<td>Exp (B) for SI</td>
<td>1.449</td>
<td>1.125</td>
<td>1.784</td>
<td>1.222</td>
<td>2.190</td>
</tr>
<tr>
<td>Sig. for SI</td>
<td>.122</td>
<td>.610</td>
<td>.036*</td>
<td>0.583</td>
<td>.086</td>
</tr>
<tr>
<td>B for 1st course Grade</td>
<td>0.689</td>
<td>0.277</td>
<td>0.428</td>
<td>0.594</td>
<td>0.510</td>
</tr>
<tr>
<td>t-value for 1st course Grade</td>
<td>9.44</td>
<td>2.66</td>
<td>3.31</td>
<td>3.56</td>
<td>1.12</td>
</tr>
<tr>
<td>Exp (B) for 1st course Grade</td>
<td>1.993</td>
<td>1.319</td>
<td>1.534</td>
<td>1.810</td>
<td>1.665</td>
</tr>
<tr>
<td>Sig. for 1st course Grade</td>
<td>&lt; .001*</td>
<td>.008*</td>
<td>.001*</td>
<td>&lt; .001*</td>
<td>.006*</td>
</tr>
<tr>
<td>B for Constant</td>
<td>-0.510</td>
<td>-0.398</td>
<td>-0.562</td>
<td>-0.590</td>
<td>-0.517</td>
</tr>
<tr>
<td>t-value for Constant</td>
<td>-0.911</td>
<td>-5.10</td>
<td>-6.04</td>
<td>-5.09</td>
<td>-1.63</td>
</tr>
<tr>
<td>Exp (B) for Constant</td>
<td>0.600</td>
<td>0.671</td>
<td>0.570</td>
<td>0.554</td>
<td>0.596</td>
</tr>
<tr>
<td>Sig. for Constant</td>
<td>.600</td>
<td>&lt; .001</td>
<td>&lt; .001</td>
<td>&lt; .001</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Model Chi Squared</td>
<td>96.639</td>
<td>7.517</td>
<td>15.884</td>
<td>13.824</td>
<td>11.016</td>
</tr>
</tbody>
</table>

Note. * Differences are determined to be significant at p-value of < .05. B = Coefficient for the constant, Exp B = exponentiation of the B coefficient, which is an odds ratio
Persistence within Community College B. The Crosstab analysis and $t$-test showed a positive and significant effect on overall persistence for Community College B. 79% versus 54% ($X^2 = 128.156, p < .001$) of students persisted when they utilized SI sessions (See Figure 4.4). Looking at course sequence, students from Community College B who utilized SI during the first course of their course sequence had a better average persistence rate (46.7%) than students who did not utilize SI (16.0%), chi-square (1, $N = 1462$) = 70.689, $p < .001$. Looking at students who persisted through Spring ‘11, there was a positive and significant effect when students utilized SI in their previous semester [$\text{Exp (B)} = 2.816, p$-value = .030, prediction rate = 87.1%]. Although not significant at the .05 level, there was a significance at the .10 for students who took SI the very first semester, ($\text{Exp (B)} = .376$). There was a positive effect for overall persistence through Spring ‘11 for students who took SI during fall ’09. The results can be found in Table 4.10. The null hypothesis for Research Question 3 is rejected.
When disaggregated into separate pairs of semester sequences and using logistic regression, the coefficient on the SI variable for the Fall ‘09 –Spring ‘10 sequence was positive and was statistically significant at the p < .05 level (t-value = 2.16). Students who utilized SI for the first course of a specified course sequence were 3.424 times more likely to persist to the next course in the sequence than those students who did not utilize SI during the first course of a course sequence. The model predicted 73.8% of the responses correctly. The next two semesters were not significant and their predictive responses were at 73.6% and 65.7% respectively. The results are found in Table 4.11.
Table 4.11

Logistic Regression Using Course Grade and SI as Variables

<table>
<thead>
<tr>
<th>Variable Analysis</th>
<th>Fall ‘09-Spring ‘10</th>
<th>Spring ‘10-Fall ‘10</th>
<th>Fall ‘10-Spring ‘11</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$ for SI</td>
<td>1.231</td>
<td>0.548</td>
<td>0.191</td>
</tr>
<tr>
<td>$t$-value for SI</td>
<td>2.16</td>
<td>0.668</td>
<td>0.431</td>
</tr>
<tr>
<td>Exp (B) for SI</td>
<td>3.424</td>
<td>1.730</td>
<td>1.211</td>
</tr>
<tr>
<td>Sig. for SI</td>
<td>.031*</td>
<td>.504</td>
<td>.666</td>
</tr>
<tr>
<td>$B$ for 1st course Grade</td>
<td>0.511</td>
<td>0.511</td>
<td>.542</td>
</tr>
<tr>
<td>$t$-value for 1st course Grade</td>
<td>1.49</td>
<td>1.14</td>
<td>1.75</td>
</tr>
<tr>
<td>Exp (B) for 1st course Grade</td>
<td>1.668</td>
<td>1.666</td>
<td>1.720</td>
</tr>
<tr>
<td>Sig. for 1st course Grade</td>
<td>.135</td>
<td>.254</td>
<td>.079</td>
</tr>
<tr>
<td>$B$ for Constant</td>
<td>0.610</td>
<td>0.780</td>
<td>0.306</td>
</tr>
<tr>
<td>$t$-value for Constant</td>
<td>2.82</td>
<td>3.02</td>
<td>1.39</td>
</tr>
<tr>
<td>Exp (B) for Constant</td>
<td>1.840</td>
<td>2.182</td>
<td>1.358</td>
</tr>
<tr>
<td>Sig. for Constant Model</td>
<td>.005</td>
<td>.003</td>
<td>.163</td>
</tr>
<tr>
<td>Chi Squared</td>
<td>11.225</td>
<td>2.350</td>
<td>4.232</td>
</tr>
</tbody>
</table>

Note. * = Differences are determined to be significant at $p$-value of $< .05$. 
Summary

The purpose of this chapter was to present the findings from the data analysis of Community College A and Community College B. The main objective of this analysis was to consider if Supplemental Instruction had any impact on course grade and if there was any effect of SI when utilizing this support service more than one semester. Data were restructured and recoded according to the type of analysis needed and the research question answered. The colleges were analyzed separately given that all students at Community College A started with a developmental math class and all students at Community College B were in college-level courses.

The results showed a significant, albeit low correlation between Supplemental Instruction and course grade for both colleges. The comparison of means predicted positive and significant results when students utilized SI versus no SI. Community College A had a mean course grade of 1.86 for students who SI compared to 1.33 for students who did not utilize SI during the semester. Community College B had similar results, mean course grade of 2.50 compared to mean course grade of 1.64.

Disaggregating the results for Community College A, both developmental and college-level courses showed that a higher course grade resulted when students utilized SI. Community College B was disaggregated into specific subjects and all three courses, math, biology, and physics showed a higher course grade when students utilized SI and the p-value was significant.

Linear regression was calculated to test if participation in SI for a development-level STEM course has an effect on the grade in the subsequent course in the sequence.
The results showed there was no impact on subsequent developmental course grade when students utilized SI for a previous course.

The independent-samples t-test was used to capture the results for students who took sequential coursework utilizing SI. This study wanted to answer the question – how much of an effect does SI have when students utilize SI for more than one course. Overall, both community colleges showed a positive impact on course grade for the second course of the two-semester sequence when students utilized SI in both semesters and the results were significant. The results were mixed when looking at semester sequence. Although there were higher mean course grades for all semester sequences, only Fall 2010-Spring 2011 was considered significant at the < .05 level for both community colleges.

Research Question 2B focused on whether there was any significant impact when students took two STEM courses in a single semester and utilized Supplemental Instruction in both courses, as compared to SI in only one of them. Only Community College B had the data to answer this question. The results revealed an overall positive and significant impact on course grades when taking SI for the second course, and when disaggregated, all four semesters showed a significant and positive effect.

The last question asked whether there was a positive and significant impact on the successful persistence of students when they utilized Supplemental Instruction. Overall, both community colleges demonstrated a positive and significant impact on course persistence. Data analyses using cross-tab and logistic regression and looking at semester sequence showed a higher percentage of students persisting through the second semester based on utilizing SI during the first semester, but only Fall 2008-Spring 2009 and Fall
2009-Spring 2010 were considered significant for Community College A. Community College B also had positive and significant results for all three semester-sequences.

The next chapter will compare the results of this study to published literature. It will also define and explain any limitations of this study as well as provide any potential impact on policies governing Supplemental Instruction. The chapter will include references to any research that may be warranted to add to the body of knowledge.
Chapter V

Conclusion

According to the report *Rising Above the Gathering Storm* (2005), the United States faces an increasing shortage of students graduating in STEM and going into in STEM-related fields. Boggs (2010) points to the recent efforts by community colleges to help reduce this shortage, such as helping students who need developmental coursework, using new pedagogies in the classroom, and articulation agreements with four-year universities, but those efforts are not without challenges. Students are still struggling to graduate from community colleges with two-year degrees in STEM or transfer to a four-year university in STEM fields. Schuetz (2002) states that more than half of the students who enter community colleges need at least one developmental course. In California, only 59% of students who took the lowest developmental course in mathematics actually succeeded in passing the course (California Community College Chancellor’s Office, 2011).

Tinto (2002) suggested five conditions for the success of a college student. Supplemental Instruction has been shown to meet two of the five conditions: providing support through academic and social experiences, and actively engaging the student in his or her own learning process. This study was conducted to see if Supplemental Instruction did, in fact, improve student success in a community college setting, and just as important, support student success among developmental students as well as when students take multiple courses that have SI as a support service.

This chapter will discuss the findings of this study as they relate to the three research questions. The discussion will follow two paths, one path for college-level
classwork and the second path for developmental coursework. This chapter will also provide implications of this specific study as it relates to college success, and more precisely, community college success. The last part of the chapter will provide limitations to the study and recommendations for further research.

Discussion

The first part of Research Question 1 that this study tried to answer was whether Supplemental Instruction has an impact on course grade when students utilize SI for three or more sessions within the course. The study used a comparison of means and also did an independent samples \( t \)-test and the Levene’s Test for Equality of Variance to verify that the means were significantly different from each other. If the Levene’s Test did not show equal variance, then the Mann-Whitney Test was also performed to measure significance.

Impact on Course Grade for College-Level Math Students. This study found an overall increase in course grade for college-level coursework when students utilized SI for that course (defined as attending three or more sessions). Course grades at Community College B were 0.86 points greater (on a 4.0 scale) when students utilized SI as a support service for that course than course grades for students who did not utilize the service. The students within the data provided by Community College B took college-level coursework within the STEM fields of math, physics, and biology. These courses are considered the gateway courses to continue with a STEM major and students will not be able to move through their major and transfer/graduate without successfully completing these courses. My study demonstrated that all three subject areas showed a higher final course grade for SI users than non-SI users and the difference of means was
significant at $\alpha < 0.05$. The largest significant difference was observed in physics courses at Community College B. Students who utilized Supplemental Instruction in Physics had an increase course grade of 1.21.

The International Center for Supplemental Instruction at the University of Missouri-Kansas City conducts a national survey of Supplemental Instruction sites. In their 2007 report the mean course grade difference between SI users and non–users was a 0.45. Similar studies such as the one conducted by Shaya, Petty, and Petty (1993) have shown a 0.5 higher course grade between students who utilized SI and those students who did not use the support service. Rath et al. (2007) also showed an increase in course grade, although the average difference was slightly less at 0.31 higher for students who utilized SI. Blanc, DeBuhr, and Martin (1983) showed a slightly smaller increase in course grade (0.38) between SI users and non-users. Blat et al. (2001) showed a higher course grade difference, with one course, network theory, having as much as a 0.851 increase in course grade between SI users and non-users.

Although most literature on the topic of Supplemental Instruction shows a positive effect on student success, not all studies show a significant difference in course grade. In the same study, Blat et al. (2001) did not see a significant increase in course grade for a previous year. What was seen was a significant difference in the number of passing grades for students who utilized Supplemental Instruction. Studies done by Collins (1982), Fest (2000), Hensen and Shelly (2003), and Moore and LeDee (2006) also show a higher rate of passing grades for students utilizing SI although there was not a significant increase in course grade.
Impact on Course Grade for Developmental Math Students. Like college-level courses at Community College B, students taking SI in a developmental level course for Community College A had a higher overall course grade of 0.53 when compared to non-SI students. Means were compared from students in the lowest level of course work (four levels below college-level math). That SI boosted grades at Community College A is an important finding, because Supplemental Instruction is usually reserved for college-level course work and is not recommended for developmental classes (Arendale, 1994). Supplemental Instruction was originally intended for students who had a basic foundational knowledge of the content in the target course, whereas students who need to take developmental course work usually are missing some if not most of the basic foundational concepts within a course.

However, there are studies that show there is an increase in course grade when using Supplemental Instruction in developmental courses. Wright, Wright, and Lamb (2000) showed a 0.4 increase and a 14% higher passing rate when students utilized SI with their developmental courses. Phelps (2006) conducted a pilot study at Valencia Community College in which four of the lowest passing courses were developmental math courses. Phelps concluded that SI did increase course grades but the level of increase was not considered significant for pre-algebra. The next two higher-level courses, beginning algebra and intermediate algebra, did show an increase in course grade and it was significant at $\alpha < 0.05$. Moore and LeDee (2006) conducted a study at a four-year university using an introductory biology course (non-major) with developmental education students. These students are similar to community college students in that they did not meet all the requirements to attend the regular four-year
university, but were admitted on a conditional basis. The study did not show any significant increase in course grade for students utilizing SI, but it did show an increase in the number of passing grades compared to non-SI users. The findings, although different from my findings in that I did show an increase in course grade with developmental classes, still prove that SI can be beneficial to developmental coursework.

**Impact of Supplemental Instruction on Progression of Developmental Course Work.** Research question 1B asked whether SI had an impact on the next progressive developmental course. A regression analysis with an ANOVA was analyzed to answer the question. Each successive developmental course became the dependent variable with the predictor variables being Supplemental Instruction sessions attended in the previous course as well as the previous course grade. The study showed that the only progression that was statistically significant for Supplemental Instruction was when students took SI at the first level below college-level coursework and then continued to the college-level course the next semester. In other words, my study examined if SI taken the semester before had an impact on not only the grade in the previous semester, but also the grade in the following semester. My study did not show this to be true. This should not discount the fact that students who utilize SI in developmental coursework have a higher final course grade in the current semester and do have lower W, D, and F grades compared to students who do not utilize Supplemental Instruction.
Impact on Course Grades when SI is Utilized in Subsequent Course Work.

Studies show that Supplemental Instruction positively affects student success with a higher final course grade (Bell, Lumpkin, Price, & Seemann, 2012; Blanc, DeBuhr, & Martin, 1983; Blat et al., 200; Rath et al., 2007; Ramirez, 1997; Wright, Wright, & Lamb, 2000). Yet, data are not available from previous studies to see if utilizing SI in consecutive semesters provides a boost in grades. Do students who use SI in two sequential courses have better course grades in the second course than students who only utilized SI for the first course? In this study, data from both community colleges were examined and filtered to obtain an answer to this question. An independent samples t-test as well as a Means Test with ANOVA was analyzed to see what type of additive effect Supplemental Instruction has on students.

This study showed that for Community College A, there was an overall increase ($\alpha = 0.001$) in course grade of the second course for students who utilized SI for two consecutive courses ($M = 2.24, SD = 1.01632$) compared to students who only utilized SI for the first course in a sequence ($M = 1.49, SD = 1.35926$). The study went further and disaggregated the data to see if this was true for both developmental and college-level course work. Students who took developmental coursework at Community College A experienced an increase in course grade for all consecutive-semester pairs, but the increase was only significant for one semester pair. The college-level courses at Community College A also had in increase in the second course of the two-course sequence. Community College B also had an overall increase in course grade between students who used SI services for two courses during consecutive-semester pairs ($M = 2.91, SD = 1.13066$) and SI users for only one course ($M = 2.43, SD = 1.22684$) at $\alpha$ level.
< 0.001. Once again, the second course within the consecutive-semester pair was used to determine the effect. Data from Community College B were also disaggregated into consecutive-semester pairs. The grades from courses taken during the second semester were higher for students who took advantage of SI for both semesters, but only one consecutive-semester pair was significant. For both community colleges, the significant consecutive-semester pair ($p < .05$) was during the Fall 2010-Spring 2011 pairing.

Data from Community College B were also analyzed to see if there was any effect on course grades when students took two courses utilizing SI within one semester compared to taking two courses within a semester, but only utilizing SI for one of the two courses. Overall, there was a higher mean course grade with $\alpha < 0.001$ when students attended SI for two classes ($M = 2.53$, $SD = 1.31486$) versus only attending SI for one class ($M = 1.68$, $SD = 1.51326$).

**Supplemental Instruction and Successful Persistence.** One of the key successes for Supplemental Instruction is persistence and eventual graduation (Bowles et al., 2008; Parkinson, 2009; Peterfreund et al., 2007). In analyzing data for Community College A using a cross-tab analysis with chi-square and an independent samples $t$-test, the overall persistence rate of SI users who earn a C grade or above and also continued to earn a C or above in the next level course was 73.4% compared to non-SI students, with the same criteria of C or above, who persisted at a rate of 54.6%. This was an 18.8% increase in the persistence rate and this rate is significant at an $\alpha < 0.001$. When disaggregated into two-semester sequences, there was a higher persistence rate for SI students than non-SI students for each consecutive-semester pair (e.g. Fall 2009-Spring 2010, Spring 2010-Fall...
2010) but only the fall-spring sequence was significant. Community College B had similar results; 79% of SI users successfully persisted versus 54% of non-SI users with \( \alpha = 0.10 \). Students who used Supplemental Instruction during the first of the semester-sequence showed an extremely high persistence rate (45.5%) compared to non-SI users (16.6%). Community College B had higher persistence rates for all three two-semester sequences and all three rate increases were considered significant at \( \alpha < 0.05 \).

**Implications of this Study**

Supplemental Instruction is a student support program geared toward reaching students in high-risk courses, courses with a large number of D, F, and W grades. It promotes engagement and effective study skills for the student (Hurley, Jacobs & Gilbert, 2006). It breaks the cycle of learned helplessness by stopping the student’s dependence on learning only from the instructor (Hurley, Jacobs & Gilbert, 2006). Students learn to work in collaboration with each other, taking “responsibility for their own learning” (Latino & Unite, 2012, p. 34). Students begin to take control of their own learning and know they have the knowledge to think more critically about the subject matter (Bean & Eaton, 2001).

It has been well documented that SI improves grades and increases retention and successful graduation (Martin & Hurley, 2005). SI is successful in both four-year universities and two-year colleges (Ribera, BrckaLorenz, & Ribera, 2012). Wild and Ebbers (2002) suggest that one of the ways to retain students is by developing programs such as Supplemental Instruction. SI has also been shown to provide a more supportive learning environment as well as reduce any feelings of intimidation (Longfellow, May, Burke, & Marks-Maron, 2008). Because SI provides time for studying outside the
classroom, it promotes social interaction, a key ingredient for student success, especially at the two-year colleges. For these reasons, this study feeds into the previous body of knowledge, but also brings forward new knowledge that can be helpful.

**Implications from Research Question 1.** As affirmed in the Supplemental Instruction National Data Fall 2003-Fall 2006 (University of Missouri, 2007), this study concluded that Supplemental Instruction does improve grades with an average of 0.5 increase in course grade. Bowles and Jones (2002) suggest that typical single OLS models may be underestimating SI effectiveness (p. 7) and that this increase could be higher than previously stated. What is important is that the results show an improvement in grades for those students taking developmental math. The effect of SI helps students in all levels of developmental math, although this effect is short-lived for the lower levels of developmental math. Students need to continue to receive Supplemental Instruction services for each successive course in order for SI to improve grades and retention.

In times of constant budget worries and decreasing support services, this study offers community colleges a clearer picture that Supplemental Instruction is a viable answer in their search for ways to increase student retention, persistence, and eventually graduation. Just as important, as community colleges should continue to keep the model of open enrollment, thus providing more support to “insufficiently prepared” (American Association of Community Colleges, 2000, p.2) students, Supplemental Instruction can serve as a safety net for students who may not be initially prepared to succeed in college. If community colleges continue to demand that students start at developmental levels based on placement tests, then this demand necessitates the colleges providing support to assist students through the full sequence of developmental coursework. This study has
shown SI does increase course grade for every level of developmental math thus SI participation should be encouraged at each developmental level.

I believe utilizing SI in developmental coursework is important given the push by community colleges to move the student through the developmental pathway. Many community colleges are turning to a first-year experience learning cohort or dual-course taking (taking two developmental courses within one semester) to assist developmental students in moving through the non-credit pipeline at a quicker pace. It is vital to assist these students with understanding the course material and also with the learning skills necessary to achieve persistence throughout college. SI provides these tools in a non-threatening way. SI engages students early in the learning process thereby building self-efficacy. Students become more prepared and more confident to successfully complete college coursework and continue until transfer or graduation.

**Implications from Research Question 2.** This study went beyond many previous studies to see how much of an effect on learning is there for students utilizing SI for more than one course. Other studies (Becvar et al., 2008; Gattis, 2000; Ogden et al., 2003) looked at the long-term impact of SI based on GPA, subject matter retention, or college graduation. This study delved deeper by asking what effect SI had on students when they took sequential classes utilizing SI or took two classes at the same time and used SI as a support service for both. This study showed an increase in course grade for both situations compared to students only utilizing SI for one course in a sequence or only utilizing SI for one course within a semester.

Just as colleges have offered SI for the most difficult courses, community colleges should begin to look at course sequence and see which set of consecutive courses prove
to be the most troubling for students. It is within this set of courses that SI should be provided to students for both semesters. This will help community colleges decide which courses and which course sequences should receive funding for Supplemental Instruction. For example, if students struggle with the elementary algebra-intermediate algebra sequence, but not with the intermediate algebra-college algebra sequence, community colleges can effectively utilize SI to assist its students in the lower division sequence.

The effect of utilizing SI in two consecutive semesters may also help students learn the study skills necessary to persist through the rest of their college career. Taking one course will aid students in using the newly learned study skills. Yet, just as learning course material is not the same as mastering it, neither is learning study skills the same as mastering them. Students in their first SI course will learn the skills that are contextualized through that particular course material. When students have an opportunity to use these same skills or even more enhanced skills through taking SI for another course in the sequence, they also contextualize these skills with a different course subject. Students are able to see how these learning skills are transferrable to all courses, not just the more difficult courses. This is important because many STEM subjects, even at the introductory level, have significant numbers of sequential courses. When this service is provided to students, their course completion will increase, thus bringing them closer to attaining a college degree.

There are two points to consider regarding the benefit of utilizing SI as a consecutive-course sequence and whether this additive effect is cost-effective to a college. In other words, is taking two courses utilizing SI great enough to warrant the funds necessary to have one student take two classes with SI services, or would it be
more efficient to have two students each taking one SI course? If the goal of the college is for completion/transfer, then this study shows the benefit of students who utilize SI for two semesters by its persistence rate as well as the course grade of the second course. This can be seen by looking at Community College A and the developmental courses. Ogden et al. (2003) and this study has shown, there is a tremendous short-term benefit of increased course grades for SI users, but Odgen et al. points out this benefit decreases over time. Reinforced learning skills acquired through students taking a two-semester sequence utilizing SI, provides the long-term benefit of persistence and continued increase course grade, outweighing the efficiency of short-term gains with more SI users.

Second, by looking at the grades, this study shows that it is definitely beneficial to have students utilize SI for a sequence of courses, rather than just utilize SI for one course. There was an increase of 0.75 in mean grade between SI users compared to non-SI users. What is important to note is that even when students utilized SI for one course, the mean grade for SI users was still not at a passing level. When students utilized SI in two consecutive courses, the mean grade for the second course was raised above the passing level. For each semester-sequence, the second course showed higher grades and except for one semester-sequence, Taking SI in the second course meant the difference between passing and not passing for many students.

Boylan et al. (1999) stated that passing developmental coursework was related to higher GPA as well as passing college-level courses. Additional studies show that low first-year GPA predicts a greater chance for students dropping out of college (Ishitani & DesJardins, 2002; Kolzow, 1986). It is vital that student grades remain high in order for students to progress to the first level of college-level math because college-level math
course is mandatory to transfer or graduate from community college. Having a higher course grade equates to increased knowledge of course material. This provides the student with a better chance of progressing to the next level and eventually progressing to college-level math.

Community College B had similar results, although not as dramatic. The mean grade between non-SI and SI students in the second course in the sequence went from 2.43 to 2.91. Both are considered passing grades and both grades are in the C range, but the second grade is close to the B average and the last of the semester-sequence did show a low C to a B grade jump. This increase is extremely important for students who are already within college-level coursework and want to progress to the upper-division courses, especially in STEM. Students who progress with higher grades in STEM during their lower-division courses have an increased chance of persistence through to graduation.

**Implications from Research Question 3.** Successful Persistence refers to students re-enrolling in the next semester. This study went further than looking at retention by not only analyzing data for students who passed a course with a C or better, but also studied successful persistence, analyzing data from the same students who re-enrolled and who also completed the next course in the sequence with a C or better for the course. Once again, this approach follows the path of student success with a goal towards graduation. The study confirmed that Supplemental Instruction increased successful persistence among students taking STEM courses. This was especially true at Community College B whereby, not only was the overall effect significant, but also all three two-semester sequences were significant.
College Accreditation teams are beginning to look at not just college enrollment, but also college completion. When students complete the Free Application for Federal Student Aid (FAFSA), there is a college completion rate stated for each college on the application. Community colleges are beginning to take the attitude of “getting students in and out” as fast as they can. SI can be one solution to facilitating student persistence until graduation. Applying Tinto’s Theory of Engagement (1987), colleges know the more engaged students are in their academic pursuit, the greater the chance of students graduating. This study has concluded that students who utilize SI not only persist, but persist at a much greater rate.

With the expectation of community colleges showing a higher transfer/graduation rate, the data clearly show that having students utilize SI for a two-semester sequence brings these students from failing to passing and from non-persisting to successfully persisting students. SI does help students, and this is especially seen in the developmental classes. Community Colleges need to look at what will bring the most students to that graduation stage and utilizing SI in a consecutive-semester sequence is a positive way to keep students engaged and successfully persisting until they do receive their diploma.

It is important to note that SI becomes a money-saving service to the institution. Congos (2002) and Zywicki (2012) both showed the savings SI can have for a college. For example, Zywicki used the formula developed by Congos at his institution, Iowa State University. For Fall 2012, the college retained over 1.75 million dollars due to students re-enrolling for the spring semester due to SI. The funds are also retained by having students complete the full semester, thus no refunds are needed because of students dropping out classes.
There is also a cost savings of SI versus tutorials. Seeing a student for one hour equals one student hour. Typically a student tutor will work ten hours per week. An SI leader also works approximately ten hours per week. A tutor will have from one to three students per work hour. Given even the maximum number of students, a tutor can only handle 30 students per week. One SI leader can see up to 30 students per one SI session. Although 30 students per SI session is on the high side, even assuming that SI sessions handle only 15-20 students per session with three SI sessions per week, the SI leader can effectively assist 45-60 students per week. This is up to a 50% increase of students being helped per week compared to tutoring. Per semester, the total is only 450 student-hours for a tutor versus 675 student-hours for an SI leader. This example only speaks of one tutor versus one SI leader. Multiply the number of students being helped by the number of SI leaders possible at a college with the percentage of students being retained and we have a winning formula. Because some students need the one-on-one experience of a tutor to learn, tutors should not be eliminated, but tutoring staff could potentially be decreased, adding to an additional cost savings for the college.

The savings cost also applies to the student. California community colleges’ passing rate for developmental coursework is 64%. That means that 36% of students will need to retake the class again in order to move ahead. This study showed an average of 20% increase in the passing rate of students, thus lowering the need to retake the same class. Students will not have to pay tuition for taking duplicate courses. Colleges reduce their expenditure on repeated courses that state and federal funds will not cover.
Study Limitations

**Threat to Internal Validity.** A major threat to this type of study was the diffusion of treatment, when the control and experimental group interacted during the study. It was possible that students who benefitted from SI could have shared what they learned during the SI sessions with other students, thus making some members of the control group more like the SI group. Although this is highly desirable for Supplemental Instruction services, it dilutes any pure separation of students who utilized SI from the start of the semester with non-SI users. Even going to SI one or two times may dilute the effect because students may have gained enough knowledge to increase their course grade with limited utilization of SI. This could have skewed comparison between the two groups of SI and non-SI users.

The amount of training and number of years of experience for SI Leaders could have caused an over or underrepresentation of potential grade increase for students. SI Leaders all have distinct personalities and how the Leaders facilitate the SI session can be more or less beneficial to the students in class. Once again, this study had no control of how the SI session was taught, or which learning aids each Leader used to facilitate the session. All of these unknowns were limitations to my study.

**Threat to External Validity.** There are also external threats to the study's validity of outcomes, the loss of generalization to a larger sample of individuals or to the population as a whole. Trochim (2006) speaks of four external threats: people, setting, time, and places. Due to the nature of this research being causal-comparative, the sample was already pre-determined. The study had no control over the demographic makeup of each class section or the demographic makeup of each SI session. This study was
conducted with community colleges, thus different results may have occurred if four-year universities had been studied.

Similar to the first threat of not being able to select a specific population is the external threat of setting and treatment. SI Leaders for both community colleges were supposed to be trained using the standard model of SI, but each community college trained their own SI Leaders. Because the study used secondary data, I could not conclude the SI Leaders were trained in a similar fashion. As stated above, there is a difference in how well students receive information about course material based on how well an SI leader is trained. Not controlling for the SI leader could have possibly decreased any potential for an increase in course grade by students who utilized SI. There was also no control for the number of courses utilizing SI for each college. Mean course grade may have been different if Community College B utilized SI within all STEM courses and not just the seven courses within the study.

This study used a cut-off point of attending three or more sessions as utilizing SI for the course. It did not further disaggregate the number of SI sessions. Since students who attended SI three or more times were in the same sample as students who may have attended as many as fifteen SI sessions, the study could not investigate the impact that attending a greater number of SI sessions would have on course grade. There may have been an under-estimation of the impact of SI due to the cut-off point being low. If the cut-off point was higher, such as eight sessions, there may have been a more substantial effect of SI on course grades.

The third threat is the history of the experiment. Would the results be the same if the experiment was carried out at a different point in time? This study tried to counter
that threat by looking at a four-semester length of time. What this study was unable to consider was whether the students who started in the selected classes in 2009 would have had the same results as students who started in the same classes in 2011. The difference in cohort start date could have made a difference with the type of student utilizing SI. Due to the economic downturn during 2008-2011, there were more second-career adults who enrolled at community colleges. Because I did not have data stating the age of each student, I could not distinguish between first-time freshmen (those directly out of high school) and any older population. Older students who attend community colleges tend to receive higher grades and are more engaged than first-time freshmen. I could not answer if better engagement from older students would translate to more or fewer students utilizing SI, thus causing the impact of SI to course grades to have different results than just using first-time freshmen.

The last threat is place; the data were received from two community colleges within relatively close proximity to each other. Although they are classified by the National Center for Education Statistics as two different types of areas (one urban, one suburban), both schools hail from the same county. The schools had similar demographic make-up of students, thus my ability to compare whether SI worked better with urban versus rural students was not possible. Even though California has pockets of rural areas, the results of this study if the colleges were in another state could have led to a different conclusion. Many states do not have the ethnic/racial make-up in their community colleges as does California. While studies have looked at the effect of SI based on based on race/ethnicity, no study has used this variable in looking at SI in consecutive semesters. These previous studies have shown that SI has a greater effect on
underrepresented students. My study showed that SI had a positive effect for both course grade and persistence when comparing consecutive-semester pairs, but the results could have been caused by a larger percentage of underrepresented students in my data and not from general population data.

Results could also be different if this study was completed with non-STEM coursework. First, there is no developmental coursework in many other non-STEM areas such as history or communications. Although SI is usually offered for those classes with high rates of poor grades and withdrawals, STEM courses are well documented to be the most difficult courses on campus. Students who utilized SI during STEM may be able to pass the course, but may not have been able to increase course grades. SI offered in non-STEM courses, where increasing a student’s grade may not be as difficult, may lead to even greater gains in non-STEM courses.

**Additional Limitations.** Originally I wanted to include several other variables in addition to course grade. I wanted to examine how SI impacted cumulative GPA. Also, my original intent was to examine the long-term effect of Supplemental Instruction for low-income students at the community college. Both colleges were unable to provide me with any data due to restrictions maintained by their Institutional Research offices. I also wanted to examine the high school GPA and use this variable as part of my regression analysis, but was unable to collect the data. Even access to data on gender was restricted at both institutions. These additional demographic data would have been used as counter-points to the regression analysis. In other words, high school GPA may or may not have affected the extent of the relationship between SI and course grades in college.
Although the original sample size was more than adequate for a full examination of the research questions, the sub-population of those students taking SI in two courses within a semester or within a two-semester sequence was considerably smaller. A sampling error will occur when there is a difference between the true population and the estimate of the sample (Cresswell, 2008).

**Further Research**

Supplemental Instruction has come a long way from the first session proposed by Deanna Martin in the 1970’s. SI is now utilized by many universities and colleges throughout the United States as well as in many developed countries around the world. Studies too numerous to count have shown the effectiveness of SI on increasing course grades and/or decreasing D, W, F grades within a course. Brinkworth, McCann, Matthews and Nordstrom (2009) showed that the transition from high school to college is difficult for many students. This transition is especially difficult for students who attend a community college, a preponderance of whom did not take the rigorous curriculum while in high school. Students enter college with notions of what to learn and how to learn, but are soon faced with the realities of college life (McGuire, 2006). Supplemental Instruction can be a stop-gap against attrition for many students in community college, particularly for students who have the desire to enter a STEM major.

What this study could not accomplish and should be considered for further research is to explore gender differences among students who attend SI. Fayowski and MacMillan (2008), Lockie, Van Lanen, and McGannon (2013), and Sax (1992) did study the impact of SI using gender as a variable, but not in relation to any long-term effect of SI. Considering numerous studies have shown that males tend to go into the physical
sciences at a higher rate than females, utilizing SI in the introductory levels of physical science classes may help retain more females in these subjects.

There is also missing information regarding underrepresented students and the effect of Supplemental Instruction within this population at community colleges. Saltiel (2011) looked at the impact of SI in underrepresented students, but there were additional support services involved other than just Supplemental Instruction. Meling, Mundy, and Green (2012) looked at math classes with Hispanic students, and Rath et al. (2007) looked at an introductory biology course with underrepresented students, but the study was conducted at a four-year university and not at a community college. Further research needs to come forward regarding SI and race/ethnicity specifically dealing with STEM coursework at the community college level.

A missing element to this study (as well as many other studies on Supplemental Instruction) is the effect of SI on the higher-level coursework found at both community colleges and after students transfer to four-year universities. SI is a support program that is successful for introductory coursework, whether it is developmental or college-level in nature. Yet, Young (2005) speaks about a “leaky pipeline” among underrepresented students in STEM. It is not the number of students who enter college, but rather the number of students who complete college with a STEM degree that needs to be addressed. One solution would be to ensure additional SI to junior-level STEM courses to reinforce critical thinking skills as well as homework and test-taking strategies in the more difficult coursework.

Although I looked at semester sequence, further research is in order when trying to find the point of diminishing returns to additional SI courses for individual students.
Further study should investigate the difference between grades when SI is not utilized, when students only use SI for one course and when students utilize SI for two courses. This would provide a better picture of how much an increase in SI use by individual students affects course grades. The information collected through this type of additional study would aid community colleges in providing better strategies for SI funding. Knowing whether providing a second SI course to one student yields a greater gain than providing two students each with only one SI course would help colleges effectively use their limited budgets in achieving student success.

**Summary**

Studies have shown (Anderson & Kim, 2006; Clewell, Cohen, Tsui, and Deterding, 2006; Palmer, Davis, & Thompson, 2010) that to retain students within the STEM fields, students need to be engaged, develop better study strategies, and feel supported throughout the process. Supplemental Instruction teaches students how to learn and has been shown to be successful in STEM coursework. It increases course grades and it reduces the number of D, F, and W’s students receive in a course. Attending as few as three sessions can increase a student’s level of knowledge for a class.

This study not only has reaffirmed what so many others have seen, that SI works, but also that it brings into focus an area which has seen little research, that of the effect of SI on students in consecutive semesters. This study showed that students who use SI perform better and persist longer than their non-SI counterparts when they have additional coursework utilizing Supplemental Instruction. It has been shown that SI improves students’ grade by as much as ½ letter grade. There is an additive effect; students continue to “learn how to learn.” This added effect could mean the difference for
students being on probation or dropping out and being retained, not only until the next semester, but to graduation. Students who utilized SI for two consecutive semesters had close to a 20% increase in successful persistence over students who only utilized SI for one semester. This type of result has added benefit in students graduating or transferring at a faster rate with less duplication of coursework for the students.

At the present time, when budgetary matters are at the heart of every educational conversation, any investment needed to incorporate Supplemental Instruction at the community colleges is well worth it. Just as important, this study showed that SI worked within STEM coursework. Students were able to persist through their developmental classes or introductory classes within STEM. When over 50% of students entering community college need at least one developmental course, using SI as a support service will not only help the student, but it will help the college. Students who are successful, and who learn how to learn, will be students who graduate with a degree. This is the heart of education, helping students to be critical thinkers so that they are successful in life. Supplemental Instruction can play a role, and possibly a large role, in ensuring the attainment of this goal.
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