# EFFECTIVENESS OF REMEDIAL MATHEMATICS SUPPLEMENTAL INSTRUCTION: A COMMUNITY COLLEGE STUDY

by

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ABSTRACT

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The purpose of this mixed method study was to determine if there is a relationship between characteristics of supplemental instructors' personal traits, teaching skills, subject matter, constructive/active, collaborative learning, effective communication, and their practices (as judged by students) and student success in their remedial mathematics course.

The college Provost was contacted by email to request an authorization to conduct this study in his college. Once approved, the investigator contacted face to face his colleagues to ask their students to participate in the study because they enrolled in a remedial algebra class where the instructor is assisted by a supplemental instructor (SI leader). Sixteen algebra classes were selected, and each were assisted by supplemental instructors. Students' scores on the pre-test (at beginning of the semester) and post-test (at the end of the semester) were collected to gauge their achievement on both tests. Students completed a questionnaire that asked about their perceptions about their

supplemental instructors' personal traits, teaching skills, subject matter, constructive/active, collaborative learning, effective communication, and their practices throughout the semester. Students' mean scores difference on the post-test were higher in 62.5% of the sections than on the pre-test.

The evaluation of achievement on both tests, the responses to the questionnaire and comments from students showed that SI leader's characteristics associated to effective communication/active learning, teaching skills, and personal traits could be contributor to score achievements. The linear regression in the study shows that the three factors did not significantly predict the post-test score. However, the pre-test did significantly predict the post-test score in a remedial Math 20 at the end of the semester (Beta = .47, $t(197) = 6.56$, $p < .05$). In addition, the comments in the questionnaire found that students acknowledged their supplemental instructor role in the classroom and during the SI's weekly sessions.

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# Chapter I

# INTRODUCTION

## Background for the Study

Only 28% of community college students who take a developmental education course go on to earn a degree within eight years (Bailey, 2009), and many students assigned to developmental courses drop out before completing their sequence and enrolling in college-level courses (Bailey; Cho & Jeong, 2010).

The number of unprepared students who enter college is high. Only 23% of those who graduated from high school in 2009 met the standard score on four ACT benchmarks in English, mathematics, reading, and science (ACT, 2009), suggesting a lack of preparedness for facing the challenges of higher education. According to Bautsch, Senior Policy Specialist of the National Conference of States Legislatures (2013) the number of high school students who enroll in college after graduation is on the rise, and many of them are unequipped with the knowledge and skills to succeed in higher education. Bautsch noted that states are working to help these students avoid remedial education through better preparation in high school. The number of students who enter college and leave without graduating shows the importance of equipping students cognitively and constructively to face the challenges of higher education and prepare them to not only pass college's entrance examinations but also courses with traditionally high withdrawal rates. Across the country, higher education institutions are determined to improve success rates in mathematics and English to increase retention and graduation rates, particularly community colleges. A number of studies (Comfort, 2011; Flek et al., 2015; Zaritsky & Toce, 2006) have been undertaken to assess the extent to which the traditional system of developmental education helps students into and through college-level coursework. One effort to address the problem is the implementation of supplementary instruction (SI).

The City University of New York (CUNY) is the nation's leading urban public university. Founded in New York City in 1847, the University comprises 24 institutions: 11 senior colleges, seven community colleges, the William E. Macaulay Honors College at CUNY, the CUNY School of Medicine, the CUNY Graduate School and University Center, the CUNY Graduate School of Journalism, the CUNY School of Law, the CUNY School of Professional Studies, and the CUNY School of Public Health and Health Policy (CUNY Office of Institutional Research, 2015). CUNY serves more than 274,000 degree-seeking students as well as 260,000 adults and continuing education students. College Now, the University's academic enrichment program, is offered at CUNY campuses and more than 300 high schools throughout the five boroughs of New York City (CUNY Office of Institutional Research, 2017).

According to the Integrated Postsecondary Education Data System, which is run by the National Center for Education Statistics, freshman enrollment at the City University of New York rose substantially at the community colleges — from 24,217 in 2001-2002 to 34,340 in 2011-2012 (NCES-DAS, 2012). Community college students represent 33% of the total CUNY student population, with most coming from New York Public schools. Of these students, nearly 80% are required to take at least one remedial

English or mathematics course as determined by the City University of New York placement examination services (CEAFE). At Hostos Community College, for instance, the Office of Institutional Research revealed that this two-year City University College had over 7,000 degree-seekers in 2017. It has been receiving the most diverse and weakest students in the CUNY system according to the Office of the President. Three-quarters of the students required at least one remedial mathematics course. These data are the result of the college’s commitment to giving opportunity to people who have traditionally been excluded from higher education.

The challenge now is to develop curriculum and put in place programs that will help new and returning students improve their grades and graduate quickly. One way to support students is through “supplemental instruction.” Supplemental instruction programs are taking place in some of the seven community colleges and eleven senior colleges in the CUNY system. According to the respective college websites, LaGuardia Community College introduced its SI program in 1993, Lehman College in 2007, Hostos Community College in 2012, and Borough Manhattan Community College in 2013. Supplemental Instruction at Lehman College, for instance, was a learning support program that focused on improving student confidence and performance in historically difficult classes. The major intention of the supplemental instruction at CUNY now is to increase retention and graduation rates and to promote excellence in undergraduate education, especially in remedial courses (CUNY Newswire, 2015).

The term “supplemental instruction program” is defined as one that aids in the growth of student academic achievement through the utilization of informal, regularly scheduled, and peer-assisted review sessions (Zaritsky & Toce, 2006). Supplemental instruction can be conducted in small groups, one-on-one interaction, asynchronous email communication, discussion boards, and hands-on practical application environments such as open laboratories, learning centers, and tutoring centers. Supplemental instruction (SI) was originally developed by Deanna Martin at the University of Missouri- Kansas City (UMKC) in 1973 (Lazari & Simons, 2003). Through a peer collaboration component, it provides students the option to continue the learning that begins in the classroom and to take ample time to grapple with concepts and ideas, work through difficult material, develop effective thinking and processing strategies, and benefit from the synergy of the group working together to solve problems. Its overall goal is to allow students to engage more effectively with difficult course content.

The three closely-related traditional goals of supplemental instruction are improvement of student course grades, reduction of attrition rates in historically difficult college courses, and enhancement of student persistence toward graduation. Supplemental instructors attempt to accomplish these purposes by using the processes of cooperative and collaborative learning to integrate instruction in learning and reasoning skills with the course content. For example, at LaGuardia Community College, the first CUNY College to implement supplemental instruction, such instruction has been credited with improving grades and reducing failure in high-risk courses (Zaritsky et al., 2006). The success of the LaGuardia program was made possible by collaboration among the supplemental instructor supervisors, the supplemental instruction leaders, the faculties, and the college administration: the “four pillars.” Since 2012, Hostos Community College a CUNY college has designed a supplemental instruction program which attempts to focus on increasing the passing rate in Math 010 (pre-algebra), Math 015 (introduction to algebra), and Math 020 (elementary algebra), as well as in City University Basic Skills mathematics and the Elementary Algebra Examination (CEAFE), which are mandatory for both registration in any college credit mathematics course and to graduate.

Researchers have provided support for the view that peer-assisted supplemental instruction is successful. Cooper (1999) argued that:

> …positive outcomes demand rigorous examination of goals, intelligent and informed planning of an implementation strategy for accomplishing planned goals, an alert eye to dynamics of the process, and a means of evaluating outcomes clearly and without prejudice. The stance of the instructor within the process, the design and maintenance of the classroom environment, and the choice of task and dialogues stand as pivotal in the work of creating a match between goals and an implementation strategy that make possible the attainment of these goals. The characteristics of instruction that can promote high-level discourse must be a natural precursor to peer group activities, not a standalone lesson that has little apparent connection to the information to be used and learned when students work together. (p. 215)

Instruction must focus on the cognitive and metacognitive strategies that students can use in pursuit of learning the lesson’s important content (Meloth et al., 1999). A supplemental instruction leader has a limited role because he or she cannot effectively assess or implement learning skills or competencies as could a professional instructor while teaching. Such leaders are trained in proactive learning and study strategies, and are considered facilitators who assist during class lectures and provide study session structures.

## Need for the study

Educators and policymakers alike recognize that algebra is an important gatekeeper course, not only for college preparation but also as preparation for the world of work (Temba & Bassoppo, 2010). To prepare students for future success, many school districts and state legislatures now make algebra a graduation requirement for all high school students (Choike, 2000). Unfortunately, surveys of American high school students have reported that many have difficulties with mathematical problems involving algebraic knowledge (National Council of Teachers of Mathematics, 2000). The City University of New York Office of Institutional Research and Assessment (OIRA CUNY, 2012) recommends that students enrolled in any CUNY Elementary Algebra developmental course, workshop, or other intervention demonstrate readiness for college-level courses in mathematics by: 1) passing the university-wide Elementary Algebra Final Exam (CEAFE) with a score of 65 or higher and 2) earning an overall average of a 74 or higher in that course or intervention.

The City University of New York (CUNY) placement test has five sections: pre-algebra, elementary algebra, trigonometry, reading, and essay writing. Unlike some examinations such as the Scholastic Achievement Test (SAT) or the Graduate Record Exam (GRE), the CUNY test is not designed to predict success; rather, this test is meant to be a diagnostic instrument used to detect deficiencies in basic skills that may impede college study performance. The City University of New York system is not the only state educational system which addresses students' readiness for college. For example, in an attempt to deal with the issue of under-preparedness for college, especially in mathematics, the Napa Valley College of California developed a 45-minute Algebra Readiness Diagnostic test which places students in one of five different remedial mathematics courses (Napa Valley College of California, 2011); at Kean College of New Jersey students are placed in either remedial mathematics Mat 090 or Mat 0902 if they fail the mathematics entrance examination (Kean University, 2016); and Borough Manhattan Community College students are placed in Math 08, 012, 051, 041, or 056 if they fail the CUNY entrance examination (BMCC Mathematics Department**,** 2012).

According to the OIRA (2012), in all 17 CUNY senior, comprehensive, and community colleges, 25,039 students were registered and tested in Elementary Algebra and Algebra in the fall and spring of 2014, and 14,001 registered in elementary algebra in 2015. Due to the higher enrollment and the lower passing rate in the CUNY mathematics entrance examination, each college is finding ways to increase student retention and achievement, particularly in pre-algebra and algebra, where students are performing poorly.

Martin's SI model, proposed in the 1980's, was validated as an exemplary program by the United States Department of Education, and its success continues as a solid intervention used in colleges and higher institutions around the world (Martin, Arendale & Associate, 1992). Supplemental instruction can yield strong results in terms of student learning, higher final course grades, and lower DFW (drop, fail, and withdraw) rates across disciplines, types of colleges, and ethnicities (University of Missouri-Kansas City, 2004). Each participating educational institution implemented this program based on its student needs. At the University of Georgia system, supplemental instruction was adopted in response to students' failing rate (30% to 50%) in introductory level science, technology, engineering, and mathematics courses (Shaw et al., 2014). Supplemental instruction was one of the alternatives the College has implemented since 2012 to help students succeed in their college remedial mathematics courses.

Supplemental instruction is designed to assist students in mastering course concepts and, at the same time, to increase student competency in reading, reasoning, and study skills. Joyce and Andi (2006) determined that by encouraging all students to attend, the model removes the stigma that students may feel when they are assigned to an academic support program; it permits all students, even those already doing well, to improve their grades and performance. A supplemental instructor, or SI leader, is required to attend all classes assigned, take notes, and assist students and the professor in or outside the classroom.

The supplemental instructors are typically students who are mathematics or engineering majors, have previously completed the course (or have taken higher-level mathematics courses), and have a good mathematics record (Flek, 2012). They are selected by the Mathematics Department and undergo extensive training in workshops that emphasize active learning. The supplemental instructors are taught to regard themselves as facilitators or coaches, not as instructors, as defined by via principles and methodology of collaborative and cooperative learning. Supplemental instructors assist in all remedial mathematics courses at the college.

Naidoo and Paideya (2015), in the context of their University in South Africa, described supplemental instruction as based on the principles of peer learning, encouraging contact between student and faculty, developing reciprocity, cooperating and collaborating amongst students, encouraging active learning, and promoting the development of study skills. Naidoo and Paideya's findings were designed with the intent of improving the current mathematics and science passing rates. A supplemental instruction program at another college provided many benefits to the institution, including to faculty, staff, and the students who received the SI services (Stout & McDaniel, 2006). A comparative success analysis over three years by Heriye, Kaan, and Selda (2014) revealed an increase in the academic success rate of the participants.

In *Applying the Seven Principles for Good Practice in Undergraduate Education* (1991) Chickering and Gamson stated:

> Student learning is less effective when students sit inertly in classes barely listening to teachers, passively viewing PowerPoint presentations, memorizing pre-packaged assignments, and spitting out answers. Learning is not a spectator sport. Student learning is optimized when students are actively involved in their own learning. Students must talk about what they are learning, write about it, relate it to past experience, and apply it in their own lives. They must make what they learn part of themselves. (p. 6)

The supplemental instruction program could be used to relate the seven fundamental active and collaborative learning goals (Encourages Contacts Between Students and Faculty, Develops Reciprocity and Cooperation Among Students Learning, Uses Active Learning Techniques, Gives Prompt Feedback, Emphasizes Time on Task, Communicates High Expectations, Respects Diverse Talents and Ways of Learning) illustrated by Chickering and Gamson.

## Purpose of the Study

The purpose of this study was to determine if there is a relationship between characteristics of supplemental instructors' practices (as judged by students) and student success in their remedial mathematics courses. These mathematics courses are key to preparing students to be successful in college for-credit mathematics classes. Students who register for these courses have to pass the course as well as the CUNY online proficiency examination (CAEFE) at the end of the semester, an indispensable path to advance toward college credit mathematics or science courses in the City University of New York system. The focus was on the students' performance and their responses to a questionnaire regarding their supplemental instructor's role during class periods and during the weekly 75-minute session.

## Research Questions

To achieve its goals, the study seeks to answer the following research questions:

1 How do students describe the characteristics of their supplemental instructors' personal traits, teaching skills, subject matter, collaborative learning, effective communication, and practices?

2 What relationship is there between these characteristics and student achievement test scores? Are certain factors associated more with high achievement and others with lower achievement?

**Procedure of the Study**

The study was conducted in an urban two-year college in the greater New York City area. The supplemental instructors were required to attend all classes and take notes during lectures. They offered a 75-minute mandatory supplemental instructor session for the whole class and an additional 75-minute voluntary supplemental instruction session per week.

To accomplish the purpose of this study, I carried out the following procedures:

1) I provided a pre-test at starting of the semester and a post-test at the end of the school year. Both tests were created by the six committee members of the remedial mathematics in which I am member at the college using the test bank and test generator (TestGen) from Pearson. Pearson was the provider of developmental mathematics text books and digital platform for mathematics and sciences in occurrence Math 20.
2) I provided the pre-test answer key and each professor graded his students, then reported me their scores. The post-test was a computerized and the professor emailed me directly the full grade just after students had completed it. I compared students' pre- and post-test scores to evaluate how the SI leaders' characteristics influenced student's scores.
3) A reliable, valid instrument developed by Dolmans and Ginns (2005) was used in the questionnaire to identify characteristics of supplemental instructors. The Dolmans and Ginns short questionnaire was based on the theoretical notions underlying contemporary constructivist approaches to learning and instruction on which the

supplemental instruction based. The alpha coefficient demonstrated acceptable levels (alpha coefficient above 0.70). The instrument was based on constructive and active learning, self-directed learning, collaborative learning, and intra-personal behavior, which are common factors for evaluation and assessment in social science. I administered at the end of the semester a twelve-item questionnaire developed by Dolmans and Ginns to evaluate supplemental instructors' effectiveness. The instrument represented six main topics: personal traits, teaching skills, subject matter, constructive/active learning, collaborative learning and effective communication on which 198 students rated their SI performance. Some students added comments in the questionnaire to reflect their opinion about the 16 supplemental instructors' characteristics and practices over the semester. In order to link student responses to a specific supplemental instructor, students were identified by the last three digits of their school identification number. Each SI leader was identified by the course section he or she was facilitating.

4) A paired sample t-test and multiple linear regression using SPSS software were conducted to determine the relation between the characteristics which students identified in the supplemental instructors via the questionnaire and students' scores on the pre- and post-tests.

## Operational Definitions

***Supplemental instruction program (SI):*** Supplemental instruction (SI) is an academic support model developed by Deanna Martin at the University of Missouri—

Kansas City in 1973 that uses peer-assisted study sessions to improve student retention within targeted historically difficult courses (University of Missouri-Kansas City, 2004). The SI program provides peer support by having students who succeeded in these particular courses help others.

***Supplemental instructor (SI leader):*** The supplemental instructors are typically students who are mathematics majors, have previously completed the course (or taken a higher-level course), and have a good mathematics record (Hostos, Mathematics Department, 2012). A supplemental instructor is required to attend all classes assigned, take notes, and assist students and the professor. The successful SI leader is able to facilitate the group so that students are the ones who generate answers to questions raised during the SI sessions.

***Supplemental instruction session:*** A regular, scheduled (75 minutes per week), informal group-setting learning session directed by a SI leader, in which students develop study skills, solve problems, and discuss solutions.

***Remedial mathematics:*** A developmental course offered to help underprepared students achieve the level of mathematics necessary to enroll in for-credit college mathematics courses.

***Algebra (MATH 20)***: A college preparatory course which is designed to supplement the algebra background of the learners prior to taking pre-algebra (MATH 10). Topics include fundamental operations with polynomials, factorization of polynomials, linear equations and inequalities, and radicals.

***Effectiveness:*** The effectiveness of the supplemental instructors was determined by using statistical techniques (SPSS and ANOVA) on the questionnaire that contained twelve characteristics describing SI leaders and their practices.

***Achievement:*** Throughout the pre-test and post-test, achievement was measured according to the students' scores on 25 elementary algebra questions. These questions were similar to those given in the City University of New York proficiency examination (CAEFE). A score of 65% or better on that exam is required to be exempt from remediation.

# Chapter II

# LITERATURE REVIEW

This literature review presents an overview of seven major topics: the focus of the first section of the review is on student failure. The portion concludes with ways of improving mathematical achievement. The second section of the literature review explores supplemental instruction (SI). The section begins with definition of SI followed by a discussion of collaborative learning, student involvement, engagement, persistence, and motivation in remedial mathematics. The third section addresses SI professional training and discusses the issue of training effectiveness. The fourth section of the literature review examines recent literature regarding the implementation of supplemental instruction in secondary education. The fifth section of the literature review focuses on technology's role in teaching and learning. This section examines the use of technology as a tool to assist students' mathematical learning. A variety of tools used to supplement learning mathematics are discussed. The sixth section of the literature review explores the role of tutors in the mathematics classroom. The section concludes with a review of literature addressing effective characteristics of an SI leader. The final section of the literature review looks at effectiveness of supplemental instruction programs in higher education.

Community colleges serve as gateways to higher education for many students. The availability of academic support programs within the community college system could directly influence academic effectiveness and achievements of students who use these services.

## Student Failure and Achievement in Mathematics

The major reasons for failing mathematics in college from the faculty's perspective are the failure to seek help when needed, lack of effort, lack of motivation, and ineffective study habits (Cherif et al., 2014). These factors as well as academic readiness and student attitudes toward mathematics are mentioned in Cherif's study most frequently as the root cause behind student failure at the college level. According to the students, lack of motivation is the leading cause of student failure (Cherif, et al., 2013). Motivation influences student attitudes, study habits, and academic readiness. At the elementary and secondary levels, teachers are sometimes able to identify struggling students and employ intervention strategies such as requiring students to attend review sessions or calling parents; in reality, this doesn't always happen, so sometimes students need to seek help of their own accord. At the college level, however, professors rarely engage in such interventions, leaving the student to take the initiative (Embong, Maidinsah & Wahab, 2014). Extra help can be sought through a variety of means, such as visiting a campus mathematics laboratory or tutoring center, using online platforms, consulting the instructor directly, or hiring a professional tutor.

Neglecting to complete out-of-class assignments or not putting the required effort into these assignments is another principal reason why students fail mathematics. Mathematics demands, among other things, accuracy of thought and statement, definite mental concepts, connected thinking, a fair memory, quickness to recognize relations between forms and numbers, the power of generalization, and a willingness to work hard. It is difficult for most minds, and grueling for some (Brousseau, 1998; Merill, 2012; Robertson, 2017). Upon viewing an instructor demonstration, students oftentimes think they understand how to solve a problem, but when they pick up the pencil to attempt a similar problem themselves, they may not even know how to begin. Mathematics consists of skills and concepts that can be gained through studying and practice. Additionally, students need to gain experience with different types of problems that are not always shown by the teacher, and the way to gain this experience is by completing assignments and even working through extra practice problems when necessary (Henrich & Burch, 2012; Kasner & Newman, 2001; Shoenfeld, 1985).

Merrill’s (2015) interviews of numerous Louisiana State University students about their experiences in high school often revealed that the emphasis was on memorizing information and that the examinations involved simply repeating the information that they memorized. After their successful academic experiences in high school, when these students take university courses they are confident that they can begin studying one or two nights before the test, memorize facts and formulas, and do well on the examinations. They get a rude awakening when this is not the case at the college level. It is essential for students to have the necessary prerequisite knowledge before beginning to study a new or higher mathematics topic. For example, many students struggle with algebra because they lack the basic arithmetic skills required to perform algebraic operations.

Another barrier to academic success is the one-size-fits-all approach to learning and assessment that contributes to the estrangement of students who are expected to adjust to academic goals and a culture not designed with them in mind, and to do so at places where they do not feel at home. Very few secondary education institutions effectively maximize the intellectual and leadership skills of their students or create effective learning environments (Malnarich, 2005; Mbugua et al., 2012). In many community colleges, students now work more than thirty hours per week, attend school part-time, raise children as single parents, pay for college, care for children at home, and worry about the affordability of going to school, all of which make them less likely to meet their educational goals. Other reasons for poor performance in mathematics among secondary students include fear, anxiety, and the misconception of the subject as difficult (Malnarich, 2005; Mbugua et al., 2012). Attwood (2014) attributed poor performance in mathematics to parental attitude, interrupted teaching, poor teaching, and dyscalculia.

Professional educators, students, and organizations like the National Council of Teachers of Mathematics and the American Mathematical Association of Two-Year Colleges offer many suggestions for increasing mathematics achievement**.** Mbugu, Kibert, Muthaa, and Nkonke (2012) were of the view that student mathematics achievement can be improved by quality teaching and learning materials as well as proper staffing, curriculum, motivation, attitudes, and fees and levies. On the other hand, Gitaari et al., (2013) were of the opinion that ways of improving achievement in mathematics include creating positive student attitudes towards mathematics, administering more examinations and quizzes, providing adequate teaching and learning materials, motivation, completion of the syllabus in time, provision of adequately trained mathematics teachers who use a variety of teaching styles, and effective classroom monitoring by the school administration.

In another vein, Vaishnav (2013) argued that each learner has distinct and consistent preferred ways of perception, organization, and retention and further noted that brain structure influences language acquisition. Some students are visual learners, while others are auditory or kinesthetic learners. Vaishnav's study found kinesthetic learning styles to be more prevalent than visual and auditory learning styles among secondary students of mathematics and claims that there are high positive correlations between the kinesthetic learning style and academic achievement. The main effects of the three variables: visual, auditory and kinesthetic are significant at 0.01 level on academic achievement.

Human cognitive ability is pluralistic rather than unitary, and leaners of any subject will make greater progress if they have the opportunity to use their areas of strength to master the necessary material (Garner, 1993). In the classroom, it is possible to motivate learners by activating multiple ways of meaning-making through the use of tasks relating to multiple intelligences. Because of the efficacy of different learning styles, it is important for the instructors to incorporate teaching activities related to each of these styles so that all students are able to achieve high standards in the course. It is rare to find all three approaches incorporated into a classroom. However, it can be done through thoughtful planning and preparation.

## Supplemental Instruction

*Definition:* The supplemental instruction (SI) model has as its theoretical underpinnings the most widely accepted learning theories. These theories emphasize information processing and student-centered learning activities, rather than simply effecting a change in the learner's behavior (McGuire, 2006). Originally developed by Deanna Martin at the University of Missouri—Kansas City in 1973 (Lazari & Simons, 2003, as cited in Rhonda, C. P., 2008), the supplemental instruction employed in this study was a means of helping students succeed in their college education. After a rigorous review process in 1981, this program became one of the few postsecondary programs to be designated by the U.S. Department of Education as an Exemplary Educational Program. The National Diffusion Network (NDN), the national dissemination agency for the U.S. Department of Education, provided federal funds for dissemination of supplemental instruction until the NDN was discontinued. As of November 1995, faculty and staff from institutions across the nation had received training to implement their own SI programs (Arendale, 2000). Supplemental instruction operates under a variety of appellations: in North American contexts, it often operates under its original name, SI; but in the United Kingdom it is referred to as Peer Assisted Learning; and in Australia it goes by the name Peer Assisted Study Sessions.

Painter (2004) identified three key characteristics of an effective SI session: (a) real time interaction, (b) teacher-to-student interaction, and (c) peer interaction. With real time interactions in class or using World Wide Web to deliver SI to the students, support leaders are able to address students’ concerns as they arise, rather than responding at a later, less convenient, time. Teacher-to-student interactions are opportunities for teachers to monitor learning and challenge students' understandings of the context of the course, which should result in proper and timely redirection. However, peer interaction within the SI setting is also necessary because it allows learners to glean knowledge and skills from one another and to share their own interpretations and explanations of course materials and concepts. Observing this type of interaction in the SI environment enables faculty members to determine the adequacy and efficiency of student skills.

*Collaboration:* Jacobs et al., (2006) stated that SI fosters collaboration because it entails the proficient use of communication principles to assist groups with conflict resolution, problem solving, brainstorming, or project development. Aside from the process of communication, internet also plays a role in facilitating interaction and collaboration among students enrolled in SI sessions. Unique tools, such as the World Wide Web and VSI (video-based supplemental instruction) have been used to encourage engagement in the learning process. In McGuire's (2006) view, these collaborative opportunities for students within SI can create occasions where students will paraphrase coursework in a variety of formats.

A method known by Muhr and Martin (2006) as employing "critical friends" is an approach in which one associate observes another associate in hopes of providing insight for improvement. This concept of change encourages discussions between students. During this time, students further explain unclear concepts and improve their skills through peer communication and collaboration with each other. Another focus, reflected in the supplemental instruction program, is the question of structuring group activity so that expertise is distributed and that there is an ethos of building on one another's ideas (Palincsar & Herrenkkohl, 1999).

*Student Involvement:* Supplemental instruction is a voluntary support program and focuses on assistance in building peer-to-peer interaction, motivation, and self-efficacy amongst students. It focuses on providing additional support, especially for courses that are characterized by high-risk (difficult), high rates of lower performance (D and F grades), and withdrawals. Naidoo and Paideya (2015) introduced supplemental instruction as a support program for first-year engineering and science students at a participating university in 2008. The supplemental instruction sessions at the university level provide students with opportunities for engagement with course content through group and paired discussions. In addition, SI allows for the explanation and discussion of key concepts, and it encompasses the use of various questioning techniques whereby immediate feedback is provided to students.

Naidoo and Paideya (2015) define supplemental instruction based on the principles of peer learning, encouraging contact between student and faculty, developing reciprocity, cooperation and collaboration amongst students, encouraging active learning, and promoting the development of study skills. The supplemental instructor helps by providing prompt feedback as well as developing metacognition. Metacognition refers to "one's knowledge of one's own cognitive processes" (Flavell, 1976). If students are cognitively aware of how they are studying, then those students may know what problem-solving plans and techniques to use and how to think about the content in order to grasp abstract concepts. Most students are not "naturally" metacognitive, and it is found that this skill tends to develop much later in students' lives (Bransford; Brown & Cocking, 2000). Supplemental instruction can assist here, since one of the major components of SI requires the SI leaders to incorporate modeling of study skills relevant to the content. Supplemental instruction leaders attempt to engage students in actively thinking about what mental processes they used when they were successful as well as what they used when they were unsuccessful (Naidoo & Paideya, 2015).

*Attitude and Role:* A supplemental instructor is a student who plans activities to help students with study skills, organization of the material presented during lecture, and learning strategies (Porter, 2012). The supplemental instruction session is a time to interact with other students in the class to better learn, understand, and apply the relevant material by asking questions, comparing notes, developing organizational skills, and engaging with the SI leader. The supplemental instruction is neither a re-lecture of the material nor a traditional tutoring session (Mathematics Department, 2016). Piaget (1952) states that students must construct their own knowledge in order to understand and use it. A consistent theme within Piaget's theory is that learning depends on equilibrium, a process involving the reconciliation of conflict between prior and newly experienced beliefs. Piaget's model of the functioning of equilibration includes two technical terms, observables and inferential conditions, each of which must always be considered from the perception of the subject under consideration. Piaget (1985) defines observables and inferences within the context of learning:

> An observable is anything that can be established by immediate experience of the facts themselves. In contrast to this, coordination involves inferences and go beyond what is observable. Such a distinction is clear, however, only when the subject is capable of objective observation and logically valid inferences. It is much harder when observations are inexact and when inferences include false implications. For that reason, it will not do to define observables only in terms of perceptible characteristics. The subject often believes he perceives things that he does not perceive. Nor will it do to characterize coordination by verbal

> formulations subjects give of them. Implicit inferences play as great role as those made partially explicit, if not a greater one. (p. 35)

As such, equilibration implies that students should be provided with beliefs that differ from their existing ones, but which, by virtue of not being too advanced, can be related to them (Foot & Howe, 1998). Thus, there is clear implication that collaborating among students ought to be productive.

Although students can learn skills from other students, supplemental instructing contexts, where one SI leader imparts information to one or all class members, may be more effective. This construction involves actively thinking about and discussing the major concepts and terms related to the field of study. Vygotsky (1978) introduced a concept called "The Zone of Proximal Development" (ZPD) that describes the gap that exists between the current knowledge of an individual student and the higher levels of learning that an expert student has in a particular discipline. Vygotsky saw the key mechanism as supported exploration through social and cognitive interaction with a more knowledgeable peer, in relation to a task whose level of difficulty is within the tutee’s ability.

Vygotsky’s (1978) zone of proximal development addresses the cognitive theoretical framework in that it identifies the margin within which learners can function with and without teacher assistance. The ZPD represents the boundary between a student’s ability to function autonomously and the point at which students need professional help in order to achieve their goals (Vygotsky, 1978). The zone of proximal development is also related to the need to work through problem situations with someone who is a good teacher and knowledgeable about the subject matter. Ideally, through continued interaction during the SI study sessions with the SI leader, learners are able to extend their abilities to the higher levels of thinking and to approach the problem-solving processes understood by the expert student.

*Student Engagement/Persistence:* At LaGuardia Community College, Zaritsky, and Toce (2006) showed that students who participated in SI were less likely to drop the targeted course and therefore more likely to persist. The persistence of students in the SI program at LaGuardia was associated in part with the synergy among interdependent groups: SI supervisors, SI leaders, faculty, and administrators. The foundation of motivation in SI, as stated by McGuire (2006), is leader engagement. McGuire examined students in institutions which implemented SI and noted that SI caused students to see course information from different viewpoints. These viewpoints engaged students in behaviors and actions that developed into interactive learning environments. In addition, this type of learning engagement was used to shift thinking from rote memorization to a higher level of conceptual thought and understanding.

In a study of high school students with learning disabilities (King-Sears, 2007), students felt that teachers should make instruction fun, exciting, interactive, and individualized by incorporating experiments and hands-on activities. According to McGuire (2006), new approaches to the learning process, such as interactive games and activities, increase the attendance of students at SI sessions. New knowledge must be constructed by the learner and the strength and truth of that construction depends on the prior knowledge to which it is linked as well as the accessibility of that knowledge (Cooper, 1999). The supplemental instructor assistance must focus on the cognitive and metacognitive strategies that students can use in pursuit of learning the lesson’s most important content.

Students' active engagement in academically focused sessions with their SI leaders may provide multiple benefits for a large and diverse population of college students (Cunningham et al., 2011; Grillo & Leist, 2013). For example, not only do these interactions help students understand or clarify difficult concepts in a content course, but additionally, these interactions may improve motivation to learn, understanding of the process of learning, and development of study strategies. Regardless of which benefit may most assist students who use academic support services, this engagement inside and outside the of the classroom seems to contribute to their academic or social integration to the extent that these students are more successful in their courses as evidenced by earned grade point average which then contributes to their retention at the university. The results of the Grillo and Leist study suggest that the positive impact of students' engagement with academic support services (tutoring, learning assistance, and supplemental instruction) is long term and associated with graduation.

*Motivation:* King-Sears (2007) report that, at the minimum, a thoughtful combination of verbal praise and attention increase the preferred level of on-task behaviors, thereby leading to the development of a higher level of conceptual thought and understanding. McGuire (2006) notes that instructors who passionately embrace SI and energetically promote it in their lectures promote increased attendance at SI sessions. An apparent lack of concern for the value of SI causes "a domino effect including lack of success in school, leading to poor self-esteem, both of which are within the control of effective teachers" (Vanderslice, 2004). Therefore, it is important that instructors focus on building relationships between students and SI instructors, emphasizing the value and relevance of SI not only to academic but also to personal life and ensuring that students experience an educational yet exciting and enjoyable atmosphere within the SI setting (Vanderslice, 2004).

Motivation in the SI setting is also an important tool for increasing graduation rates. Lockie and Van Lanen (2008) revealed that the attempt to assist first and second year students to effectively improve academic performance in science courses through an SI-based curriculum yielded positive and desirable results. Furthermore, Bowles, McCoy, and Bates (2008) reported that if students are naturally motivated and decide to attend SI, graduation rates increase. Bowles et al. (2008) assumed that, due to the impact of SI on graduation rates, at-risk learners would be more inclined to participate in SI sessions. Various studies (Gningue et al., 2014; Schunk, 1998; Web & Farivar, 1999) have shown that when learners can learn in a way that suits them, motivation and improvements in the effectiveness of the learning process normally ensue.

## SI Professional Training

Supplemental instructors (SI Leaders) are usually sophomore or junior undergraduates majoring in mathematics, science, or engineering (Porter et al., 2012). In general, students who appear in their interviews to be eager to demonstrate their knowledge of the content material, express interest being a leader for the sole purpose of reviewing course content, or seem dismissive of students who struggle with issues like time management and note taking should cause concern for the SI supervisor. These attitudes are addressed in training, but with the average leader training lasting only 4 to 8 hours, it is expedient to select individuals who already believe in supporting educational access for all students, a philosophy on which collaborative learning and the SI model are based.

Several researchers showed evidence that SI leaders were effective when they received focused training (Comfort, 2011; El-Aziz El Naggar et al., 2013; Huges, 2011). For this reason, Zaritsky and his colleagues (2006) at LaGuardia Community college provided an intensive workshop training to SI leaders prior to the start of the semester with the following major objectives: (1) to introduce students to how SI works; (2) to help students understand the nature of SI and how it is different from other academic support programs; (3) to introduce students to basic theories of learning; (4) to model and have them practice strategies associated with cooperative and collaborative learning; (5) to review various study skills; (6) to discuss behavioral issues they may encounter and how they may approach them; and (7) to view and analyze videotapes of exemplary SI sessions.

Emphasizing particular approaches based on constructive learning theory during training allows the prospective leaders to practice facilitating student-to-student interaction. Professionals in the field of education understand that teaching and learning is a complex task, but undergraduate students sometimes underestimate the planning it requires.

Although the supplemental instructors have opportunities to interact with faculty and students on a personal level, they still may not feel comfortable with the communication patterns that successfully build professional relationships. When they participate in the SI program, they must engage in structured activities in order to fulfill their duties as facilitators. One approach considered to be instrumental in improving instructional methods is Bloom's (1971) learning for mastery theory. The learning for mastery theory provides guidelines for course design that focus primarily on how learning processes are structured for mastery. Furthermore, the theory provides an active foundational model for self-pacing and responding by providing a systematic process of tutoring infused with repeated testing. This process of testing with the objective of mastery is related to what McGuire (2006) defines as meaningful learning: developing knowledge through the analysis and synthesis of previous levels of knowledge.

Skills in synthesis are seen as allowing students the opportunity to interpret and manipulate information as a practice or concept that may be applied practically in realistic situations. The rote-meaningful learning continuum is defined as reception and discovery of instruction. The learner must consciously choose to learn meaningfully by seeking connections and not default to rote memorization. Meaningful learning is a process in which new information is related to an existing relevant aspect of an individual's knowledge structure. The learner must actively seek a way to integrate the new information with the existing relevant information in her cognitive structure. The school can encourage this choice by using resources such as SI to help students move toward high level of meaningful learning. McGuire (2006) concluded that implementation of rote-meaningful learning continuum strategies improved conceptual understanding and increased students' overall examination grades.

The most popular approach to evaluate training in organizations is Kirkpatrick's four-level model for assessing training effectiveness. The framework model delineates four levels of training outcomes:  reaction, learning, behavior, and results. Evaluation should always begin with level one, and then, as time and budget allow, should move sequentially through levels two, three, and four (Kirkpatrick, 1957). This model can be applied before, during, and after training to both maximize and demonstrate training's value to the organization.

Kirkpatrick defined "reaction" as measures of how participants reacted to the training, "learning" as measures of what participants have learned from the training, "behavior model evaluation" as the measurement of the degree to which participants applied what they have learned during training when they are back on the job, and "results" measures whether the application of the training is a contributor to a better score for the student.

## Implementation of SI

Supplemental instruction is designed to assist students in mastering course concepts and, at the same time, to increase student competency in reading, reasoning, and study skills. Whereas SI was explicitly designed not to target "at-risk" students but was perceived as offering help for difficult courses (Arendale & Martin, 1993; Blanc et al., 1983), it stands to reason that some academic and learning support communities will have considered whether a successful intervention like SI could be particularly useful for students who may not be as well prepared for college study. In many cases these students come from under-represented population groups such as lower income families, ethnic minorities, or international students. The question is whether the design features of SI could be particularly useful in enhancing the academic performance of students who may not have done well in more "traditional" teaching and learning environments. More “traditional” pedagogical approaches, which are often premised on students at higher education levels being able to absorb, process, and make sense of large amounts of information through transition-style delivery models, may be exactly the reason why certain groups have under-performed (Van der Meer; Scott, & Neha, 2010).

In order to assist two-year college freshmen and returning students, the SI leaders attend the course lectures, where they take notes and complete assigned work with the students in and after lectures (Porter et al., 2012). The SI leader is presented as a "student of the subject."  As such, the leader presents an appropriate model of thinking and language behavior in the field. The leader's job, then, is to demonstrate proficiency in the subject while providing quality instruction, for instance, in the reading, writing, mathematics, and thinking skills necessary for content mastery (Palincsar & Herrenkkohl, 1999). Each instructor defines the resource person's role in accordance with what the instructor thinks is appropriate. This role varies somewhat according to the nature of the discipline and the instructor's teaching style and priorities.

The Mathematics Association of America (MAA, 2008) asserts the need to develop pedagogies that could be used effectively to facilitate students’ mathematical abilities. In essence, the MAA advocates for an increase in student-centered teaching and learning and a decrease in teacher-centered pedagogy. One assumption is that an increase in student-centered teaching will result in increased student engagement in mathematics and, by implication, this increased engagement will lead to increased student achievement. For example, various researchers argue that students are more engaged and achieve more when teachers relate new learning to prior learning and model problems, provide them with a variety of opportunities to apply, and use knowledge and skills in different learning situations (Rosenshine, 2012). Supplemental instruction has been found to produce positive cognitive, social, and affective outcomes over a broad range of target populations (such as the academically handicapped or socially disadvantaged) and settings (such as special and regular classes) (Chapman, 1998).

If learners are taught how to take responsibility for their own learning and are encouraged to develop intrinsic motivation from an early age, this could have a significant impact on overall academic achievement in mathematics and related fields (Naidoo et al., 2015). In this way, more learners will be adequately prepared to enter careers utilizing mathematics and science. Chapman argued that in order to meet the needs of specific target students or contextual constraints (such as time or resources) it is sometime necessary to adopt or extend specific components of selected approaches. Naidoo and Paideya (2015) suggested that the SI model be introduced at the secondary school level in an attempt to assist learners in developing subject-specific learning skills in the hope of developing independent learners who feel equipped and confident in their ability to successfully complete traditionally challenging course material.

## Technology's Role

Technology in modern society has many uses. However, in the field of SI, it is important that educational leaders employ new approaches for using technology in the development and implementation of SI (McGuire, 2006). Technology may be able to help learners realize the benefits and contributions of SI as a foundational tool for learning.

The main concept of technology in SI is represented by a new educational trend discussed by Jonassen, Howland, Moore, and Marra (2003).

The new trend emphasizes the importance of learning with technology, rather than learning from technology. Johnson and Hegarty (2003) note that adult learners have made significant progress in literacy due to the use of internet technology and that the learning disability population learned best from computer applications such as text, graphics, blended sound, and animation. Online homework and testing management systems, for instance the WebAssign online platform developed by Aaron Titus (North Carolina University) and Larry Martin (North Park University) (James, 2013), have been commercially available since 1998. Students have access to WebAssign learning tools resources in a variety of styles (reading as eBook, watching video lectures, practicing, mastering, and practicing at different levels). WebAssign also offers the user many features, announcements, personal study plans, grades, calendars, notifications, assignment extensions, and editing.

As reported by Khan (2016), the process of assisting students to learn in an online forum offers many advantages on the road to success. The online forum offers learners an opportunity to be anywhere in the world and learn at their own pace in a synchronous or asynchronous environment. According to Painter et al., (2006), using a mixture of technologies in supplemental instruction is a necessity in the online format. These technologies include electronic whiteboards, audio conferencing, text chat, and video.

The format of SI in the website arena is used to allow for interactivity and collaboration, which are expected to enhance student interest. At the University of Akron, Elicker et al., (2008) focused on the impact of technology-based learning environments on students. Elicker et al., (2008) wanted to determine the usefulness of web-enhanced websites with chat rooms, discussions boards, and email (compared to learning environments that did not implement technology) and to see whether they would change a student's level of classroom interactivity. The study showed that by the end of the semester, "Students using the enhanced site earned more points in the class than students using the basic Web site" (Elicker et al., 2008, p. 126).

Painter et al. (2006) and researchers at the University of Missouri—Kansas City (2005) note that the asynchronous learning option of video-based supplemental instruction, or VSI, allows learners to process new material at their own pace. The option is used to allow individuals to pause and gain feedback as well as insight from the material before progressing to more course content. The opportunity to stop, pause and think provided by the VSI technological learning system is used to provide a forum for breaking information into smaller pieces for clarity, rather than handling large quantities of material all at once. The use of VSI offers an acceptable format for the instructor to act as a model student by demonstrating the mindset of how to think and learn about course materials. In addition, a VSI course can provide the foundation for consistency of content. Painter et al., (2006) noted that a course taught via video by a single professor provides a basis for evaluation of all students taking the course as well as for a supplemental instructor or tutor (p. 78). Jacobs et al., (2006) cited the VSI format as a necessary reality in postsecondary education, especially in populations that may have been neglected or formerly overlooked.

Computer-assisted instruction, a platform which evolved from offering learning tools to students for the improvement of educational presentations (Edyburn, 2005), is facilitated through enhanced levels of instructional materials and design methodologies. Furthermore, computer-assisted instruction is a blended advancement of instruction using the standard classroom-based format, intertwined with technology. This format is used to help improve at-risk students' interactions, motivations, and learning (Li & Edmonds, 2005). Computer-assisted instruction brings with it several potential benefits as a teaching/learning medium. These include self-paced learning, self-directed learning, the exercising of various senses, and the ability to represent content in a variety of media. With self-paced learning, learners can move as slowly or as quickly as they like through a program while with self-directed learning, learners can decide what they want to learn and in what order.

Riley, Beard, and Strain (2004) defined assistive technology as a service or device used as a tool by a disabled person to maintain or achieve a functional activity. Assistive technology devices are used as supplemental tools to boost student learning outcomes rather than supplemental learning replacements. Assistive and instructional technologies as methods of instruction and learning consist of both high technology and low technology. High technology devices include computers, environmental control systems, and communication boards. Low technology devices include modifications and intervention devices, such as virtual manipulatives. Virtual manipulatives, which include auditory text recorders, talking word processors, handheld scanners, and text readers, provide opportunities to explore current concepts of learning.

In societies with higher incomes, society members harness technology in different formats. Internet tutoring has replaced telephone tutoring, and it is used as an SI tool for instructors and students at a distance (Bray, 2006). The service, offered through a whiteboard, voice, text, and video software platform, has been a success, leading legislators to develop the United States "No Child Left Behind" (2002) legislative strategy to improve the poor pass rate for mathematics courses in the United States.

## Role of Tutors

In the teaching and learning of mathematics, supplemental instruction represents a convenient tool for mastering subject matter. It provides student-centered learning environments and complementary activities that enable individuals to study multiple levels of complexity and deepen understanding (Land et al., 2012). Brousseau (1988) stated that the "milieu" (physical, social, or cultural environment) plays a role in teaching and learning. He argues that human contact provides a proactive educational relationship in the classroom and beyond. For this reason, modeling and implementing supplemental instruction seems useful in learning mathematics and science through human interaction. Brousseau believes that a good instructor must have strong subject matter knowledge and strong pedagogical skills in order for him or her to model the teaching and learning environment and to provide relevant responses to ongoing learning processes.

The analysis of supplemental instruction interactions often highlights frequently occurring behaviors. The SI leader asks initiating questions, and partners give preliminary answers. The leader gives feedback, leading to iterative cycles of questions, answers, feedback, and prompting, which the supplemental instructor uses to assess partner comprehension (Topping & Ehly, 1998). The leader's contribution to the learning process includes giving reviews, summaries, reminders, analogies, prompts, didactic explanations, advice on which steps to take, corrective feedback, hints, and encouragement, as well as asking questions, diagnosing misconceived knowledge, and assessing missing knowledge and deviations from the ideal (Brousseau, 1998). Behaviors of the SI leader include giving answers, asking questions, thinking, writing, and exhibiting confusion.

A survey by Baum (2016) one faculty perspective about supplemental instruction effectiveness in a statistics course revealed five characteristics a supplemental instructor leader should have: a good conceptual understanding for the course material; good mathematical notation and terminology; the ability to clearly explain mathematical concepts; responsibility and discipline in his or her own work; and good rapport with students as well as teachers. In the eyes of faculty, the most beneficial parts of an SI program are an SI leader who has the characteristics just mentioned and students who regularly take advantage of the SI sessions. Having an SI leader who just works homework problems for the students instead of guiding students through the process was not seen as leading to student success. Such a practice might lead to a better homework grade, but is that what student success is?  Student success is how well the student understands the material and whether the student retains the information after the test (Baum, 2014; Grillo & Leist, 2013; Naidoo & Paideya, 2015).

The characteristics of a good tutor can be placed in three domains: knowledge, skill, and attitude. Under "knowledge" the good tutor should know the goals of the curriculum, the learning objectives of the course that he or she is tutoring in, the available learning resources, principals of assessment, and group dynamics (El-Aziz El Naggar et al., 2013). His or her set of skills should include facilitating learning, problem solving, critical thinking, group dynamics or conflict resolution, and assessing the students individually and as a group. In order to be more successful, the tutor should have a productive attitude. He or she should be comfortable with supplemental instruction philosophy and adopt a positive attitude toward SI as a learning method.

The personality of the tutor is also a factor that students consider when seeking extra help (Bonhs & Flynn 2010). Students feel that traits associated with a good tutor are empathy, patience, sensitivity, diplomacy, friendliness, intuitiveness, supportiveness, responsiveness, and care (Saunders, 2009). If the students feel that the tutors are arrogant or not empathetic to their concerns, they are unlikely to continue getting help from the tutor. Students who feel more affection towards their tutors or professor are more likely to seek extra help and attend SI sections (Flek et al., 2015).

According to Jacobs et al., (2006), SI has consistently showed success regarding cost effectiveness, and with both large groups and diverse populations. Furthermore, integration of SI has helped students to view course material from different perspectives, leading to active and collaborative problem solving (Lockie & Van Lanen, 2008). SI has been reported to increase feelings of confidence, thereby increasing motivation (Duranczyk et al., 2006). According to a study of a freshman student cohort in New York City, feelings of confidence and motivation developed for many students during SI tutoring sections and led to high levels of academic achievement (Flek, 2012; Porte et al., 2015). Thus, SI resulted in greater levels of academic success and fewer instances of failure.

Bloom (1971) hypothesized that if students are given ample time, 95% will achieve mastery of course material. He noted that a personally-paced type of instruction will work best for students who have diminished academic ability and knowledge, as they will gain more from this model of instruction. Li and Edmonds (2005) referenced the effects of computer-assisted instruction for at-risk mathematics students and indicated that with technological tools, students gain instant feedback and can follow a productive pace for them, thereby reinforcing facts and knowledge. Bloom (1971) noted that scaffolding, or guided practice and weaning of instruction, is a theoretical educational tool that promotes high levels of cognitive development. Hizer, Schultz & Bray (2016) found that the in-person (traditional) SI program at California State University San Marcos has demonstrated increases in grades and lower fail rates for science and mathematics courses which are being supported. They concluded that both the online and traditional SI participating students had higher course grades and lower failure rates as compared to students who did not participate in either form of SI.

Participation in SI or peer learning programs by its very nature enhances students' opportunity to meet other students and potentially develop new friendships. Although not every SI program explicitly states these social benefits in its design intentions, student evaluations of SI typically yield comments that confirm this benefit (Dawson et al., 2014; Norton & Agee, 2014). Dobbie and Joyce (2008) as well as Mahdi (2006) conducted a number of focus groups with students who attended their peer learning programs. The results from their small qualitative project suggested that students appreciated this aspect of attending SI sessions. The authors remarked that students from abroad particularly valued the opportunity to make new friendships and enhance "peer responses" in English composition class. They also emphasized the important role that this can play in students' integration into university life.

A review of the literature revealed that a majority of incoming students who enroll in community colleges need a developmental course in mathematics. SI, a form of peer learning, is a nationally recognized academic support program that has been used effectively to aid learner performance, retention and academic success. The program offers invaluable assistance to individual learners, including those who enroll in developmental mathematics.

Of the empirical studies reviewed, researchers described SI as a strategy for improving learner performance, retention, and graduation rates. Further, studies suggested that SI improves the grades of specific student populations: minority, nontraditional, low-risk, and high-risk learners. Moreover, the literature identified theories from Tinto and Pusser (2006) as well as Tatum (2000) that link SI to a climate of achievement for diverse learners through academic and social integration in an interdependent learning community.

Research indicated that implementation of SI may be hampered unless both students and teachers perceive the course to be difficult. Gaps in existing research also supported a need to further examine the utility of SI in creating a climate of achievement for learners, particularly those who enroll in developmental courses. The number of community college students who enroll in these courses and their low success rate in the absence of intervention suggested a need for additional research. Finally, a review of the literature revealed that most of the research on SI has been performed quantitatively and, thus, substantiated the need for greater qualitative research, such as this empirical study.

## Effectiveness of SI programs

The effectiveness of SI is to some extent framed by three claims validated by the U.S. Department of Education. First, students participating in SI within the targeted high risk courses earn higher mean final course grades than students who do not participate in SI; second, despite ethnicity and prior academic achievement, students participating in SI within target high-risk courses succeed at a higher rate (withdraw at a lower rate and receive a lower percentage of failing final course grades) than those who do not participate in SI; and, third, students participating in SI persist at the institution (re-enroll and graduate) at higher rates than students who do not participate in SI (Dawson et al., 2014). The most common measures of effectiveness that were reported by Dawson and colleagues described final course grades and course completion rates, followed by studies that controlled for a range of factors such as prior achievement, motivation, and college grade point average. The authors confirmed in their meta-analysis research for SI effectiveness that the claims for SI participants of improved grades in the course, fewer course withdrawals, and higher retention rates have been repeatedly substantiated. They noted that seven included studies tested for significance between the mean of the two groups (SI participants and non-SI participants) and found that these differences were statistically significant.

# Chapter III

# METHODOLOGY

This mixed method study was conducted in an urban community college in New York City. At the college, students who register in remedial mathematics classes are automatically enrolled in supplemental instruction courses. The supplemental instructors (SI's) are required to attend all regular class meetings (Mathematics Department, 2015). The data collection consisted of a pre-test and a post-test followed by a questionnaire to assess students' satisfaction with the SI leaders' roles in the classroom. The pre- and post-test were prepared by the remedial mathematics' committee in which the investigator a member. The questionnaire to evaluate the effectiveness of tutors developed by Dolmans et al., (2005) was based on constructivist approaches to learning. The common principles utilized by constructivists include active or constructive learning, self-directed learning, contextual learning and collaborative learning. In addition, modern theories on teaching and learning stress that the SI leader's intra-personal behavior is important. The instrument in this study was based on these insights and included items on the six main topics mentioned: active/constructive, self-directed, contextual and collaborative learning, and communication and interpersonal.

## Setting

The study was conducted in sixteen algebra classes (Math 20) taught by adjunct lecturers and professors during the 2016 academic year. Each these classes was assigned a supplemental instructor and met five times per week (75 minutes a day). A supplemental instructor was required to attend classes, made himself available to help students while the class was in session and when allowed by the professor (Dias et al., 2016). Each supplemental instructor was required to conduct a "tutoring" session in one of the scheduled day of classes (75-minute session) in which students could bring questions from the class lectures, homework, prior tests or examinations, or from the workbook. The SI leader would provide assistance with strategies and procedures to solve and use to get to the right answer by asking typical questions. The professor and the instructors are not present during these sessions. Math 20 is a developmental college preparatory course which is designed to supplement the algebra background of the learners prior to taking pre-algebra (Math 10) or for those who failed the City University of New York Assessment Tests (CAT) in mathematics.

The investigator provided the answer keys to the instructors who used the pre-test (Appendix D) and the post-test (Appendix E) as in-class tests. The pre-test was administered during the first week of September, and the post-test during the second week of December. The post-test is similar to the CAEFE examination. A score 65% or above was considered at the college as high achievement and the student is exempted from additional remedial mathematics courses. On the last day of class, participants were asked to answer a short questionnaire dealing with the specific SI characteristics and practices (Appendix F).

## Participants

The population in the study consisted of 215 freshmen who failed the CAT and volunteered to take the pre-test and posted of the study at the beginning and the end of the semester. The questionnaire was successfully completed by 198 of the total participants. (The decreasing number of students who responded to the questionnaire was mainly due to absences or late arrivals.)  All study participants were enrolled in remedial algebra (Math 20) classes, where each instructor is assisted by a supplemental instructor. The participants scored less than 57% on the City University of New York Assessment Tests (CAT). The CAT is the first placement examination that is a pathway for admission to CUNY Colleges. To pass its readings section, students must score 55%; to pass the writing and mathematics portions, students need 56% and 57% respectively. The CAT mathematics examination is designed to measure students' knowledge of two major mathematics topics: elementary algebra and college-level mathematics. For further details of the CAT examination, refer to Appendix G.

The Math 20 final exam, like the CAEFE, consists of 25 multiple-choice questions. It measures students' readiness in the areas of:

*Operation*s: radicals, scientific notation, and exponents

*Variables and expressions*: translating quantitative verbal phrases into algebraic expressions, adding and subtracting monomials and polynomials, multiplication of a monomial and binomial by any degree polynomial, dividing a polynomial by a monomial where the quotient has no remainder, and factoring.

*Equations and Inequalities*: translating verbal sentences into mathematical equations, solving all types of linear equations in one variable, systems of linear equations, solving literal equations for a given variable, quadratic equations, and linear inequalities in a single variable.

*Functions and functional notation*: using function notation to compute a single output for simple linear and quadratic relationships.

*Coordinate Geometry*: slope and equations of a line, drawing and recognizing graphs of lines.

*Proportions and percent*: solving simple verbal problems with two quantities that are proportional, solving simple verbal problems involving a single percent and/or a single percent increase/decrease.

At the beginning of the semester, the supplemental instructors attended a four-hour training session. The SI coordinator presented the program, defining expectations and working strategies for the SI leaders (SI coordinator, 2016). The SI leaders were students from the college or recent graduates. They had already successfully completed the course and were now re-enrolled in the same course for the purpose of facilitating study sessions (Flek et al., 2015). All leaders in the study are non-native speakers of English. They are majoring in seven different mathematics, science and engineering fields. Two were Electrical Engineering, four Civil Engineering, three Mechanical Engineering, three Chemical Engineering, one Biology-Pre Med, one Accounting, and three Mathematics majors and attending four-year colleges in the city (SI coordinator, 2016).

The Mathematics Department hired the supplemental instructor based on their academic standing in mathematics. SI leaders have the title of College Assistant. They must complete the assigned homework given by the instructor. The SI leader must be prepared to address, in a collaborative fashion, any of the course and section-specific mathematics problems that might arise during the SI sessions. The supplemental instructors act as mentors by modeling leadership, appropriate study skills, and problem-solving strategies. As members of the student body or as recent graduates, SI leaders strive to offer an unintimidating perspective to students studying developmental mathematics.

The SI leaders at the college, in addition to the beginning-of-semester training, meet every two weeks to discuss any concerns with the program coordinator and to share their classroom experiences. During these meetings, SI leaders hand out their lesson plans for their tutoring sessions and sign their time sheets.

## Questionnaire/Instrument

The instrument developed by Dolmans and Ginns (2005) to evaluate the effectiveness of tutors in problem-based learning was used to identify characteristics of effective supplemental instructors. The instrument consisted of statements for which students were asked to indicate their level of agreement on a Likert scale (1 through 5) with 1 representing “never,” 2 “rarely,” 3 “sometimes,” 4 “often,” and 5 “always.” One statement was “The supplemental instructor gave constructive feedback.” Another was “The supplemental instructor ensures student participation in the learning process.” Dolmans & Ginns (2005) demonstrated that their instrument is reliable and valid if at least six students’ responses are available for a given tutor.

The questionnaire was revised in minor ways for clarity because participants in this study are mostly ESL students. The 12-item questionnaire in Appendix F was administered at the end of the semester to gain feedback from students on their supplemental instructors’ characteristics as well as ways in which SI leaders’ implemented skills in the classroom developed through their regular meetings with peers, their instructor, the SI coordinator, and their supervisors. In addition, students were asked to provide comments and tips for improvement on their responses.

## Statistical Analysis

Participants’ scores on the pre-test and the post-test were compared in attempt to determine how SI leaders’ characteristics and practices influenced student achievement throughout the semester. The investigator ran a factor analysis that allowed him to examine which possible factors could be used to predict higher scores on the post-test based on student’s responses to the questionnaire and their pre-test score. The SI leaders spent five days a week with the students. Class attendance as well as SI sessions were mandatory. Therefore, getting student insight into the sessions’ effectiveness was important. Standard statistical techniques (average, standard deviation for achievement record, paired sample t-tests, data distribution, and correlation factors, multiple linear regression) were used to generate a quantitative analysis using SSPS software.

## Achievement Measure

Participant achievement was measured using a pre-test and a post-test of 25 algebra questions, similar to those given in the City of New York elementary algebra final examination (CAEFE). The pre-test covered three topics: 1) operations with integers and rational numbers (topics include computation with integers and negative rationales, the use of absolute values, and ordering); 2) operations with algebraic expressions (topics include the evaluation of simple formulas and expressions, adding and subtracting monomials and polynomials, multiplying and dividing monomials and polynomials, the evaluation of positive rational roots and exponents, simplifying algebraic fractions, and factoring); and 3) solving equations, inequalities, word problems (topics include solving linear equations and inequalities, solving quadratic equations by factoring, solving verbal problems presented in an algebraic context (including geometric reasoning and graphing), the translation of written phrases into algebraic expressions, and radicals). Since the CAEFE covered the Math 20 curricula, the investigator provided a computerized post-test to each professor and instructor based on the CAEFE final examination questions.

For the purpose of this study, the investigator was interested in students' scores on the pre-test and post-test. He used the cut score determined by the institution. Students who scored 65% and above are considered to achieve the algebra (Math 20) requirements. The means and the standard deviations on the pre-and post-tests were calculated and a paired sample t-test was used to compare student achievement between both tests.

## SI's Characteristic Evaluations and Feedback

Evaluation of the supplemental instructors' performance during the thirteen-week period was one of the tools used to evaluate the outcomes of the SI training workshop that all supplemental instructors attended earlier during the fall semester.

The investigator examined the possible impact of factors describing effectiveness of a SI leaders. Since the subjects were identified, the investigator was able to determine relationships between students' answers to the questionnaire and their scores on the pre-test and post-test. By using those relationship described by the students in the questionnaire, the investigator determined which factors were associated with higher or lower achievement.

# Chapter IV

# RESULTS

## The First Question of the Study

The first question of the study was: How do students describe the characteristics of the supplemental instructors' personal traits, teaching skills, subject matter, constructive/active, collaborative learning, effective communication, and their practices?

Students were asked to rate their own SI's performance in terms of characteristics that contributed to their performance and score in the course. The rating for each item was placed on a five-point Likert scale where 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, and 5 = Always.

The students rated highly their respective supplemental instructor on the 12-item questionnaire. The mean rate for each SI varies between 4.69 and 4.92 (s.d = .33, five-point Likert scale). The lowest scoring characteristics deal with "engages, motivates," "maintains student's attention," and "shows many possible ways to solve a problem." The highest scoring characteristic deals with the SI responding to students' questions in appropriate language.

The conforming factor analysis showed that the internal consistency of data was appropriate for factor analysis (KMO = .8500), and the Bartlett's test was significant (Bartlett = 1075.321, $p < .001.$ Characteristics that were not significantly loaded into one of the three components were removed, reducing six dimensions of the instruments to three dimensions without reducing the total variance explained by the data. Table 1 shows the factor loadings after rotation using a significant factor criterion of .3. The scree plot confirmed the findings for the remaining three factors.

Table 1: Rotated component matrix of the 12 characteristics loaded into 3 factors after extraction.

| Characteristics | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Responds to students' questions in appropriate language. | 0.783 | | |
| Ensures students participation in the learning process. | 0.755 | | |
| Uses correct vocabulary and grammar in speaking and writing | 0.745 | | |
| Allows students to present their solutions to their peers. | 0.673 | | |
| Is organized in presenting solutions | | 0.857 | |
| Answers with confidence students' mathematics questions | | 0.808 | |
| Has an appealing personality with good sense of humor | | | 0.838 |
| Has some good relationships with the students | | | 0.790 |

*Extraction Method: Principal Component Analysis.*
*Rotation Method: Varimax with Kaiser Normalization.*
*a. Rotation converged in 5 iterations.*

The factor loading explained the interactions of the variables with each of the 3 factors. Teaching skills, effective communication/active learning, and personal traits were the factors loading after the Varimax rotation. Given the number of extracted eigenvalues (Table 2), effective communication /active learning have the greatest effect on the total variance of student's responses (eigenvalue = 4.990). This factor explained 41.583% of the variance. The second most determinative factor was teaching skills (eigenvalues = 1.825), and it explained 15.210% of the variance. The third largest factor was personal traits (eigenvalue = 1.063). The variance explained by this factor was 8.861%. In total, 65.65% of student's response to the characteristics variances is explained by these factors. Individual SI leaders' effectiveness factors influenced students' score in the post-test.

The factors that students believed could contribute to high achievement in Math 20 were effective communication/active learning, teaching skills and personal traits. These results supplemented previous research which found that student achievement can arise from instructional and language scaffolding strategies within the SI sessions (Comfort, 2011; El-Aziz El Naggar et al., 2013; Huges, 2011).

Table 2: Total variance explained by the characteristics from the questionnaire.

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 4.990 | 41.583 | 41.583 | 4.990 | 41.583 | 41.583 | 2.954 | 24.620 | 24.620 |
| 2 | 1.825 | 15.210 | 56.793 | 1.825 | 15.210 | 56.793 | 2.872 | 23.932 | 48.553 |
| 3 | 1.063 | 8.861 | 65.654 | 1.063 | 8.861 | 65.654 | 2.052 | 17.102 | 65.654 |
| 4 | 0.958 | 7.984 | 73.638 | | | | | | |
| 5 | 0.632 | 5.265 | 78.903 | | | | | | |
| 6 | 0.497 | 4.143 | 83.045 | | | | | | |
| 7 | 0.439 | 3.659 | 86.704 | | | | | | |
| 8 | 0.419 | 3.488 | 90.193 | | | | | | |
| 9 | 0.357 | 2.975 | 93.168 | | | | | | |
| 10 | 0.327 | 2.725 | 95.893 | | | | | | |
| 11 | 0.283 | 2.359 | 98.251 | | | | | | |
| 12 | 0.210 | 1.749 | 100.000 | | | | | | |

*Extraction Method: Principal Component Analysis.*

The report of the comments in Table 3 revealed students' opinions about their SI leaders and how their conceptions and attitudes toward mathematics have changed.

Terms “teaching ability,” “personal traits,” and “communication” are associated with the comments related to the characteristics of an effective supplemental instructor.

Table 3**:** Written comments about SI’s characteristics and practices.

| Typical comments about the SI leader performance |
|---|
| • Tries different ways to solve a problem.<br>• The leaders created good synergy in the classroom by encouraging group work and providing different ways to solve a problem.<br>• Alex explained the concepts very well and was able to explain it more than one-way if I did not understand right away. He made class very interesting.<br>• He did not give the answer right away. He made you think first.<br>• Creates group work.<br>• He was very organized during the SI session, and was able to answer all math questions.<br>• The SI leader removes my math anxiety.<br>• Is an excellent tutor.<br>• He made sure I got it.<br>• Good individual help and giving personal attention.<br>• Was great.<br>• Has a great sense of humor.<br>• He helped in understanding the material as well as being nice and friendly to all students.<br>• His humor is awesome.<br>• Is very friendly.<br>• The SI leader was extremely helpful and really helped me understands the material.<br>• Is always on time.<br>• Establish a friendly and familial environment.<br>• Kierra has a great communication skill; her explanations are short and helpful.<br>• She provided a great environment in the lab.<br>• He knows all student’s names.<br>• For speaking English as a second language, Omar has an excellent command of it.<br>• Explains concepts thoroughly in a clearly, concise manner.<br>• His explanations were simple to the students.<br>• I was never afraid to ask questions.<br>• He did not hesitate to repeat or rephrase questions.<br>• Makes an effort to help students most in need during class and during his sessions.<br>• That encouraged me to ask questions in class and my other class too.<br>• He makes me not afraid of math.<br>• I participated more in this class without fear of math.<br>• [It] helped me understand the math much better. Math was not my thing. |

*Teaching ability:* Developmental mathematics students have generally been unsuccessful with traditional instructional methods and materials. SI appears to have played a major role both in the seemingly daunting task of teaching students how to learn and in motivating them to learn. SI was an important mechanism for introducing students to the learning process, engaging them in collaborative learning activities, and providing a collegial environment that increased motivation in learning. One student mentioned how his SI leader conducted the session: "Alex explained the concepts very well and was able to explain it more than one way if I didn't understand right away. He made class very interesting." Effective supplemental instructors in remedial Mat 20 were able to present mathematics solutions in different ways, providing the students with help in order to have in-depth understanding of the concepts and problem-solving strategies.

*Personal traits:* Care for the students was validated as the most effective characteristic for SI leaders. They developed a trusting and respectful classroom atmosphere, giving personal attention to learners. A good relationship was built with the students, and that allowed SI's to provide better mathematics assistance. The students mentioned being actively involved in their math class activities and in other courses as well. Their attitudes towards mathematics improved, and their mathematics anxiety diminished. The SI leaders encouraged students to work in groups to come up with different ways of solving problems. Students were able to exchange techniques and reflect upon their own thoughts.

*Effective communication/active learning:* The National Council of Teachers of Mathematics (NCTM) included communication in its Principles and Standards for School Mathematics (2000) as one of five process skills that should be incorporated into mathematics classrooms. Students need to be given the opportunity to speak, listen, read, and write in the mathematics classroom. The comments revealed that the SI leaders communicated clearly and in a concise manner. A student reported that one of the leaders was not a native English speaker but that he made himself understood by repeating or rephrasing questions and explanations. Students appeared to appreciate the precision of mathematical language. Because the supplemental instructors were taking the course for a second time (after already doing very well in it or in an even higher-level math course), they were in a position to resolve any possible student misconceptions.

Students' comments suggested that they needed a SI leader who recognized the importance of interpersonal relationships. All students who remained in the course did so because of a common goal: passing the CUNY examination. The effective interaction between other students was also important because when they collaborate, they join a community of knowledgeable peers. Lockie and Van Lanen (2008) discussed "share knowing" and collaboration, which refers to the process of students getting to know one another quickly and intimately and their getting involved socially and intellectually. This process promoted cognitive development as well as students' appreciation of their ability to enhance learning potential.

Students experience the learning process and activities with the supplemental instructors differently on a variety of levels; as one student mentioned, "I am not sure that I would have successfully completed the course without Steve's help." Although different supplemental instructors conducted the sixteen SI sessions, students agreed on the majority of reasons they appreciated being with and learning from their SI instructors. Students indicated in their comments that they got along with their SI leader. A student reported that the friendly environment during the sessions motivated him to persist in the course. Another one said: "mathematics was not my thing;" however, she gained confidence and improve her grade. The study demonstrated how valuable students considered the SI leader's role. Some comments mentioned a link between participation in the SI section and a boost in confidence about mathematics.

## The Second Research Question

The second research question asked was: What relationship is there between these characteristics and student achievement test scores? Are certain factors associated more with high achievement and others with lower achievement?

This question was intended to examine the relationship between difference in pre- and post-test scores and characteristics of SI leaders. The question examined possible SI characteristics (as viewed by students) that effected their achievement. The paired sample test (Table 4) shows a significant difference average difference scores in favor of the post-test in four sections (section 3, 11, 15 and 16). The mean differences were between 8.119 and 23.860 with a degree of significance of 2.14 to 4.298. They all were evening sections and had a small class size. Out of the 54 students in these 4 sections, 15 were returning, 6 were transfers, 4 were repeating the class, and the others passed the pre-Algebra course (Math 10) during spring or summer workshops. Students' post-test mean scores in ten other sections (1, 2, 3,4,5,9,11,12,15 and 16) were higher than those in pre-test. The paired sample t-test, however, revealed no significant difference in the pre-test and post-test in these sections.

The paired sample t- test, however, showed that students' average scores are significantly different at 95% confidence level in favor of the pre-test in only two sections (section 6 t (17) = 3.421, p < 0.003 and in section 14 t (16) = 4.217, p < 0.001).

Table 4**:** Paired sample test: post-test versus pre-test

| Evening Sections | Tests | Mean Difference | Std. Deviation | t | Df | Sig.(1tailed) |
|---|---|---|---|---|---|---|
| 3 | Post-test-Pre-test | 13.375 | 11.747 | 3.221 | 7 | 0.015 |
| 11 | Post-test-Pre-test | 23.857 | 20.791 | 4.293 | 13 | 0.001 |
| 15 | Post-test-Pre-test | 8.188 | 15.298 | 2.141 | 15 | 0.049 |
| 16 | Post-test-Pre-test | 13.750 | 16.482 | 3.337 | 15 | 0.005 |
| **Daytime Sections** | **Tests** | **Mean Difference** | **Std. Deviation** | **t** | **Df** | **Sig.(1-tailed)** |
| 1 | Post-test-Pre-test | 10.333 | 15.933 | 1.589 | 5 | 0.173 |
| 2 | Post-test-Pre-test | 8.200 | 15.835 | 2.006 | 14 | 0.065 |
| 4 | Post-test-Pre-test | 2.727 | 13.275 | 0.681 | 10 | 0.511 |
| 5 | Post-test-Pre-test | 2.700 | 14.379 | 0.84 | 19 | 0.411 |
| 6 | Post-test-Pre-test | -16.944 | 21.011 | -3.421 | 17 | 0.003 |
| 7 | Post-test-Pre-test | -8.750 | 24.187 | -1.447 | 15 | 0.168 |
| 8 | Post-test-Pre-test | -5.875 | 16.899 | -1.391 | 15 | 0.185 |
| 9 | Post-test-Pre-test | 12.300 | 18.142 | 2.144 | 9 | 0.061 |
| 10 | Post-test-Pre-test | -7.286 | 18.839 | -1.023 | 6 | 0.346 |
| 12 | Post-test-Pre-test | 1.167 | 13.687 | 0.362 | 17 | 0.722 |
| 13 | Post-test-Pre-test | -7.286 | 18.839 | -1.023 | 6 | 0.346 |
| 14 | Post-test-Pre-test | -19.353 | 18.924 | -4.217 | 16 | 0.001 |

Table 5 shows the overall rating (4.50 to 5.00) of the SI leader on F1: effective communication/active learning, F2: teaching skills, F3: personal traits, the 3 extracted factors and the students' average scores on the pre- and posttest in each section. Students believed that these factors contribute in one way or another to achievement in mathematics. Students 'overall average score increased in ten out of the 16 sections.

Table 5**:** SI leader overall rating on F1: effective communication/active learning, F2: teaching skills, F3: personal traits; and students' pre-test and posttest scores (average mean, standard deviation, sample size)

| SI Leader /Section | Factor F1 Mean(st.d) | Factor F2 Mean(st.d) | Factor F3 Mean(st.d) | Test | Mean (st.d) | Sample size N |
|---|---|---|---|---|---|---|
| 1 | 4.88(.35) | 5.00(.00) | 4.75(.46) | Pre-test | 66.67(26.49) | 6 |
| | | | | Post-test | 77.00(14.91) | |
| 2 | 5.00(.00) | 4.90(.32) | 4.75(.37) | Pre-test | 65.60(20.77) | 15 |
| | | | | Post-test | 73.80(13.69) | |
| 3 | 5.00(.00) | 4.88(.35) | 4.63(.52) | Pre-test | 57.00(23.69) | 8 |
| | | | | Post-test | 70.38(14.18) | |
| 4 | 5.00(.00) | 4.93(.27) | 4.86(.36) | Pre-test | 76.00(15.49) | 11 |
| | | | | Post-test | 78.73(11.88) | |
| 5 | 5.00(.00) | 5.00(.00) | 4.89(.32) | Pre-test | 58.8(22.33) | 20 |
| | | | | Post-test | 61.50(19.47) | |
| 6 | 4.86(.36) | 4.71(.61) | 4.86(.36) | Pre-test | 78.22(15.72) | 18 |
| | | | | Post-test | 61.28(19.44) | |
| 7 | 4.94(.25) | 4.88(.34) | 4.50(.73) | Pre-test | 67.00(19.89) | 16 |
| | | | | Post-test | 58.25(24.83) | |
| 8 | 4.86(.53) | 5.00(.00) | 4.64(.63) | Pre-test | 82.50(10.72) | 16 |
| | | | | Post-test | 76.63(14.45) | |
| 9 | 5.00(.00) | 5.00(.00) | 4.58(.67) | Pre-test | 51.60(16.70) | 10 |
| | | | | Post-test | 63.90(15.01) | |
| 10 | 5.00(.00) | 4.83(.39) | 4.75(.45) | Pre-test | 76.57(21.47) | 7 |
| | | | | Post-test | 69.29(16.58) | |
| 11 | 4.88(.35) | 4.67(.71) | 4.63(.52) | Pre-test | 56.57(22.73) | 14 |
| | | | | Post-test | 80.43(13.50) | |
| 12 | 4.94(.24) | 4.83(.38) | 4.56(.70) | Pre-test | 76.22(20.33) | 18 |
| | | | | Post-test | 77.39(15.15) | |
| 13 | 5.00(.00) | 5.00(.00) | 4.86(.38) | Pre-test | 76.57(21.47) | 7 |
| | | | | Post-test | 70.20(16.18) | |
| 14 | 5.00(.00) | 5.00(.00) | 4.77(.44) | Pre-test | 80.71(12.02) | 17 |
| | | | | Post-test | 61.35(20.04) | |
| 15 | 5.00(.00) | 4.93(.27) | 4.86(.36) | Pre-test | 64.50(20.07) | 16 |
| | | | | Post-test | 72.69(13.95) | |
| 16 | 5.00(.00) | 4.94(.25) | 4.81(.40) | Pre-test | 67.75(20.83) | 16 |
| | | | | Post-test | 81.50(11.73) | |

A multiple linear regression was conducted to see if the pre-test, effective communication/active learning, teaching skills and personal traits (independent variables) predicted the student's post-test scores (dependent variable) (Table 6). Using the enter method it was found that pre-test, effective communication/active learning, teaching skills and personal traits explain a small amount of the variance in the post-test ( F (1,197) = 42.991, $p < .05$, $R^2 = .180$, $R^2_{Adjusted} = .176$). The model explained 18% of the dependent variable (post-test). Only the pre-test significantly predicted the post-test score in a remedial Math 20 at the end of the semester (Beta = .47, t (197) = 6.56, $p < .05$).

Table 6: Multiple linear regressing of post-test, pre-test, F1: effective communication/active learning, F2: teaching skills, F3: personal traits

Model Summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .424[a] | .180 | .176 | 18.29 |

a. Predictors: (Constant), Pre-test

b. Dependent Variable: Post-test

Coefficients

| Unstandardized Coefficients | | Standardized Coefficients | | | 95.0% Confidence Interval for B | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B | Std. Error | Beta | t | Sig. | Lower Bound | Upper Bound | Zero-order | Partial | Part | Tolerance | VIF |
| 37.807 | 5.261 | | 7.186 | .000 | 27.432 | 48.182 | | | | | |
| .470 | .072 | .424 | 6.557 | .000 | .329 | .612 | .424 | .424 | .424 | 1.000 | 1.000 |

a. Dependent Variable: Posttest

Appendix I shows that the three factors: communication/active learning, teaching skills and personal were not contributor in the post-test score prediction. The current study was unable to statically assessed factors that could be associated to higher or lower achievement  in remedial mathematics (Math 20) based on the students' self-report about their SI's characteristics. This was in due part by students rated each supplemental instructor with an average 4.5 to 5 on the five-point Likert scale. The scores on the three factors had very small variance. Thus yielded to insufficient data source for assessing these factors.

The data contained significant outliers in the pre-test and the post-test. The residual are were not normally distributed. The violations of residuals, linear relationship between the dependent and independent variable as well as the existence of outliers, the present data collected failed to provide meaningful information about the factors of SI associated with higher or lower achievement on post-test.

# Chapter V

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## Summary

Supplemental instruction (SI) is an academic support model developed by Deanna Martin at the University of Missouri–Kansas City (UMKC) in 1973. SI, a nationally-recognized program offered in many higher education institutions, provides free, peer-facilitated group study sessions for certain historically difficult courses (30% D, F, and withdrawal rate). The supplemental instruction sessions provided a safe and non-threatening learning environment which allows students to try out different learning strategies and select those which work best for them (Blanc et al., 1983). The supplemental instruction leader has the ability to lead students in the discovery of how they learn and how they control their own learning. Students who are aware of their own cognitive processes can gain metacognitive skills that will last them beyond this course. Thus, an improvement in metacognitive skills can lead to a long-range improvement in study skills.

SI leaders succeeded previously in the course had a good academic standing in the subject and trained to supplement in development mathematics course. Supplemental instruction leaders are usually referred by faculty and have demonstrated competence in the course. A supplemental instruction session is not a lecture or re-lecture of the course concepts nor is it a traditional tutoring session. Supplemental instruction leaders are graduate students who attend all class lectures and take notes. So, they are aware of some of the challenges students in different sections or courses encountered during the lecture. Thus, they are prepared to answer those challenges in supplemental instruction sessions. They also assist the instructor during the class. Attending supplemental instruction session is mandatory for every student in the program.

Students normally bring questions to the supplemental instruction sessions. These questions can be from class lectures, homework, prior tests or examinations, or the textbook. Supplemental instruction leaders would typical ask probing questions to get students to explain their thoughts or procedures used in arriving at the answer. Supplemental instruction leaders would share effective study plans or test taking strategies that they used. They integrate 'how to learn' and 'what to learn' in supplemental instruction sessions. Students also share what works for them in studying or solving problems. There is also review for tests or examinations in supplemental instruction sessions. They are presented as model students of the subject. As such, they present an appropriate model for thinking, organization, and subject mastery.

Supplemental instruction operates under a variety of appellations. In North American contexts it often operates under its original name, SI, but in the United Kingdom it is referred to as Peer Assisted Learning, and in Australia it goes by the name Peer Assisted Study Sessions. SI, involving informal, regularly scheduled, learning strategies and peer-assisted sessions is commonly used to develop intrinsic motivation and overall academic achievement in mathematics and science courses (Naidoo et al., 2015; Zaritsky & Toce, 2006).

This study was conducted in a New York City urban community college that enrolls a diverse group of freshman, transfer, and adult students. The remedial Math 20 course in the study was designed to prepare students for success in for-credit college mathematics classes. Students who registered for this mathematics course must pass the class as well as an online proficiency examination with 65% or higher at the end of the semester. These two conditions are prerequisites to register for a college credit mathematics, biology, chemistry, or physics course at the college. The SI leaders were required to attend classes five days a week and to assist (tutor) students at an SI session for 75 minutes one day every week.

Providing academic support through the Supplemental Instruction Program gives students the opportunity to receive free in- and out-of-class help that focuses on active learning. Led by an SI instructor, students are able to attend sessions to receive conceptual help while reviewing class material, developing study strategies, and collaborating with classmates. Since Math 20 is required for future mathematics coursework, proper academic help within the college is an opportunity for students to succeed in mathematics and for the class and college to increase retention through the collaboration between supplemental instructors (SI leaders), students, and professors.

This mixed method study sought to examine the relationships between characteristics of supplemental instructors' practice (as judged by students) and student success in their remedial mathematics courses. The City University of New York requires all high school students and returning adults to take and pass a placement test in mathematics (arithmetic and algebra). Scores determine whether the student is exempt from remedial courses. The college involved in this study was working to assist students in avoiding taking or repeating remedial courses through better supplemental instruction assistance in mathematics.

The investigator identified SI characteristics related to student success in remedial mathematics. A questionnaire (adopted from the Dolmans and Ginns 2005 short questionnaire) to evaluate the effectiveness of tutor was distributed in 16 Math 20 sections in which students rated their SI on 12 characteristics. Responses were collected for statistical analysis using SPSS software. A pre-test consisting of 25 multiple-choice questions was administered before the SI leaders took active roles in their respective sessions. At the end of the semester, a post-test was administered, a computerized examination similar to the City University of New York proficiency algebra examination (CEAFE). It consisted of 25 multiple-choice questions representing all material in the Math 20 curriculum. Both tests were created by the remedial mathematics committee members of the college. Scores were compared to determine which, if any, SI leaders' characteristics and practices were associated with student's high achievement scores in the post-test through the questionnaire.

## Conclusions

**Question 1: "How do students describe the characteristics of the supplemental instructors' personal traits, teaching skills, subject matter, constructive/active, collaborative learning, effective communication and their practices?"**

The examination suggests that the most effective SI leaders have good relationships with students, show many possible ways to solve a problem, and use correct vocabulary and grammar in speaking and writing. Overall, the respondents believe that their SI leaders acted professionally and knowledgeably to carry out the supplemental instruction principles.

Students in the program perceived the SI leaders as engaging, motivating, and helpful in providing constructive feedback. In addition, students appreciated the group work synergy during the SI tutoring sessions. Students perceived an enrichment of their experiences within the Supplemental Instruction program. The experiences produced a sense of satisfaction, increased student self-confidence in asking questions, facilitated working in-group to solve problems, and stimulated a greater level of responsibility in their learning process.

Students' comments suggest that communication is important in developing effective interaction within the classroom. The use of appropriate language in speaking, writing, and responding to students' questions are essential attitudes that students believed to be contributors to their mathematics success. Effective communication is related here to the SI leaders' ability to create environments in which the students value mathematics discussions. Comments on the questionnaire demonstrated that the most effective SI's explain concepts thoroughly in a clear and concise manner. The SI were able to communicate effectively using correct vocabulary and grammar through speaking and writing with their tutees. In a multi-linguistic institution, in which English is a second language for many students, it is necessary sometimes to adopt the role of a foreign language teacher to explain mathematical concepts as well as new words or phrases to the students. The most effective SI's gave students more confidence in asking questions. In addition, an SI leader is the "model student," a facilitator who helps students to integrate course content, learning, and study strategies. The SI leader's competency was an important contributor to achievement for students who were attending classes five days per week.

In the exploratory analysis, the eigenvalue was calculated for each factor extracted and was been used to determine the number of factors to extract. A cutoff value of 1 was used to determine factors based on eigenvalue. The principal method default in SPSS extracted uncorrelated linear combination of the variables (characteristics). It gave the first the first factor maximum amount of explained variance (41.58%). All following factors explained smaller (15.21%) and smaller (8.86%) portions of the variance and are all uncorrelated with each other. After extracting the factors in SPSS, the Varimax method (orthogonal rotation) was used to produce factor loading that are either very high (1) or very low (.5), making it easier to match item with a single factor. In the orthogonal rotation method emerged our 3 factors: effective communication/active learning, teaching skills and personal traits rather than four.

Overall, supplemental instructors appeared from the students' responses and comments in the questionnaire to influence students' achievement scores. The factor analysis of the questionnaire responses produced a model of three factors: effective communication/active learning, teaching skills and personal traits. These factors explained about 66% of the variance after rotation of the 12- characteristics and practices of an effective supplemental instructors.

**Question 2: "What relationship is there between these characteristics and student achievement test scores? Are certain factors associated more with high achievement and others with lower achievement?"**

The paired sample test shows a significant mean score difference in six out of the sixteen sections between the post-test and the pre-test. The current study revealed that in ten sections where student's post-test score went up and were significant in four sections while their pre-test score went down in six sections and significant in two sections. It was noticed that participants in the evening classes had higher scores in the post-test than those in morning or afternoon classes. This study showed that the supplemental instructors have some positive effects on students' scores. This achievement difference supports some previous research findings on SI and non-SI mathematics courses (Flek, 2012; Porte et al., 2015) that SI leaders help students to raise their overall grades in mathematics. There were significant scores difference in favor of the pre-test in only two sections and not significant in other four sections.

Sixty-three percent of the students scored higher on the post-test than on the pre-test. This achievement could be attributed to the supplemental instructors' characteristics and practices as observed and defined by the students. The characteristics correspond with the ability the SI's had to show many ways to solve a problem, to have good relationships with the students, to answer students' mathematics questions with confidence, to respond to questions in appropriate language, to ensure students' participation in the learning process, and to have an appealing personality with good sense of humor. The students' comments suggested that these factors could be best associated to a higher score in their remedial mathematics course (Math 20).

The current study was unable to generate a meaningful linear regression equation to predict the dependent variable: post-test and the independent variables: pre–test and the loaded three factor (effective communication/active learning, teaching skills and personal traits). The lack of variance in students' self-report of their SI's characteristics constituted a particular effect in the model. Statistically, the student's responses to the questionnaire about their SI performances were not a helpful data source for identifying factors that could be associated with high /lower achievement scores in remedial mathematics (Math 20).

## Recommendations

To aid in the manageability of the current study, the researcher could omit multiple data collection sequences and use one type of test tool—either a paper test or computerized test based on students' preferences. The research question number 2: "What relationship is there between these characteristics and student achievement test scores? Are certain factors associated more with high achievement and others with lower achievement?" could be reworded to better get students' insight of factors they believed contributing to higher or lower score in remedial mathematics as “What are the most effective factor(s) of your supplemental instructor you believe affected you the most your mathematics studies?” to focus only on students’ self-report.

Use of the supplemental instruction model with SI leaders for remedial mathematics students continues at the college. Additional quantitative research is necessary to track students’ academic performance in subsequent mathematics courses and also in the science courses that have been assigned supplemental instructors. A comparison between SI and non-SI students’ mathematics performance, graduation rate, and possible attitude changes toward mathematics (or science) might provide additional support for the effectiveness of the SI model in urban community colleges.

Another recommendation would be to conduct quantitative research to examine the difference in scores of those who regularly attended SI, partially attended, and those who failed to attend the SI sessions for the same instructor. An examination of the attendance practices variable could allow the investigator to explore the impact of SI leader practices on students’ academic success for non-credit mathematics courses. At the same time, the researcher could assess both homework completion and class test scores over a semester in relation to participants’ attendance.

This study did provide full answer to the final question 2: “What relationship is there between these characteristics and student achievement test scores? Are certain factors associated more with high achievement and others with lower achievement?” A researcher could investigate this question in non-remedial mathematics courses and non-freshman setting where supplemental instructors are available.

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Appendix A

Teachers College's IRB Approval

TEACHERS COLLEGE
COLUMBIA UNIVERSITY

*Teachers College IRB* *Exempt Study Approval*

To: Bakary Sagna
From: Curt Naser, TC IRB Coordinator
Subject: IRB Approval: 16-412 Protocol
Date: 07/21/2016

Thank you for submitting your study entitled, "*Effectiveness of Supplemental Instruction in Urban Community College: Remedial mathematics*;" the IRB has determined that your study is **Exempt** from committee review (Category **1**) on 07/21/2016.

Please keep in mind that the IRB Committee must be contacted if there are any changes to your research protocol. The number assigned to your protocol is **16-412**. Feel free to contact the IRB Office by using the "Messages" option in the electronic Mentor IRB system if you have any questions about this protocol.

# Appendix B

## Research Approval letter

From: JOHNSON, RHONDA
Sent: Wednesday, August 17, 2016 5:13 PM
To: SAGNA, BAKARY
Subject: Granted Permission for Research at Hostos Community College

Dear Professor Sagna,

I am happy to inform you that Provost Mangino has authorized your research on the Hostos campus. If I can be of any assistance, please do not hesitate to contact me.

Sincerely,

Professor Rhonda L. Johnson

Head of Access Services/Assistant Professor

Hostos Community College Library

475 Grand Concourse, A-308

Bronx, NY 10451

Work: (718) 518-4214

Fax: (718) 518-4206

Email: rhjohnson@hostos.cuny.edu

Appendix C

Consent Form

**Protocol Title**: Effectiveness of Supplemental Instruction in Urban Community College: Remedial mathematics

**Principal Investigator: Bakary Sagna, Ed.D.C.T, Teachers College**

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**INTRODUCTION**

You are being invited to participate in this research study called "Effectiveness of Supplemental Instruction in Urban Community College: Remedial mathematics." You may qualify to take part in this research study because you are over 18 years old, have registered in math 020 class. Approximately seven hundred fifty people will participate in this study and it will take a total of 220 minutes of your time to complete.

**WHY IS THIS STUDY BEING DONE?**

This study is being done to determine if there is a relationship between characteristics of the supplemental instructors' practice (as judged by students) and student success in their remedial mathematics courses. The investigator will use a factor analysis to generate multiple 'profiles' of SI types. Then he will be able to see if a particular type is more strongly associated with higher (or lower) test scores. This will potentially identify characteristics that SIs should have (or that could be developed) in order to be 'effective' SIs.

**WHAT WILL I BE ASKED TO DO IF I AGREE TO TAKE PART IN THIS STUDY?**

If you decide to participate, you will be given on the first week a pre-test and post- test on fourteenth week. The pre-test and the post-test questions are similar to those on CUNY Elementary Algebra Final Exam (CEAFE). Your professor will administer these two tests in class and will take 75 minutes each. You have to identify yourself by your school identification number (ID) and you do not need to provide your name on either document. The investigator will then collect your scores for analysis only.

Finally, you will be asked to complete a questionnaire that will be used to identify potential characteristics that supplemental instructors should have or that could be developed in order to be more effective SIs in remedial mathematics. This will take about 20 minutes. You will not indicate your name in order to keep your identity confidential. All of these procedures will be done in your classroom during class periods.

## WHAT POSSIBLE RISKS OR DISCOMFORTS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

This is a minimal risk study, which means the harms or discomforts that you may experience are not greater than you would ordinarily encounter in daily life while taking routine physical or psychological examinations or tests. However, there are some risks to consider. You might have anxiety to take a math test or feel embarrassed to evaluate others trying to help you. However, you do not have to divulge anything you have done on the tests and on the questionnaire. You can stop participating in the study at any time without penalty. The principal investigator is taking precautions to keep your information confidential and prevent anyone from discovering or guessing your identity, such as using a pseudonym (your four digits' course section) instead of your name and keeping all information on a password protected computer and locked in a file drawer.

## WHAT POSSIBLE BENEFITS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

There is no direct benefit to you for participating in this study. Participation may benefit the field of teacher education to better understand the best way to recruit and to train mathematics supplemental instructors in urban community college.

## WILL I BE PAID FOR BEING IN THIS STUDY?

You will not be paid to participate and there are no costs to you for taking part in this study.

## WHEN IS THE STUDY OVER? CAN I LEAVE THE STUDY BEFORE IT ENDS?

The study is over when you have completed the pre-test and the post-test and filled out the questionnaire. However, you can leave the study at any time even if you haven't finished.

## PROTECTION OF YOUR CONFIDENTIALITY

The investigator will keep all written materials locked in a desk drawer in his home. Any electronic materials will be stored on a computer that is password protected. There will be no record matching your real name with your four digits' course section. Regulations require that research data be kept for at least three years.

## HOW WILL THE RESULTS BE USED?

This study is being conducted as part of the dissertation of the principal investigator.

## WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?

**If you have any questions about taking part in this research study, you should contact the principal investigator, Mr. Bakary Sagna, at 646-851-5641 or at**

**bsagna@hostos.cuny.edu. You can also contact the faculty advisor, Dr. Vogeli at 212-678-3381)**

**If you have questions or concerns about your rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu. Or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 1002. The IRB is the committee that oversees human research protection for Teachers College, Columbia University.**

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**PARTICIPANT'S RIGHTS**

- I have read and discussed the informed consent with the researcher. I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.
- I understand that my participation is voluntary. I may refuse to participate or withdraw participation at any time without penalty to future student status or grades; services that I would otherwise receive.

The researcher may withdraw me from the research at his or her professional

**INFORMED CONSENT**

- The researcher may withdraw me from the research at his or her professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue my participation, the investigator will provide this information to me.
- Any information derived from the research study that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- I should receive a copy of the Informed Consent document.

**My signature means that I agree to participate in this study**

**Print name**: ______________________________________ **Date**: __________________

**Signature:** _______________________________________

# Appendix D

## Mathematics Pre-Test

Student: ________________________________________ date: / /

Pre-test
Name________________________________ Date: / /

**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

**Write the following using exponents.**

1) $(5w)(5w)(5w)(5w)(5w)$ 1) ______

A) $(5w)^6$ B) $25w^5$ C) $25w$ D) $(5w)^5$

**Simplify.**

2) $240 \div 12 - (4 + 3)$ 2) ______

A) 16 B) 19 C) 48 D) 13

**Evaluate.**

3) $x^3 + 2 + y$ for $x = 1$, $y = 3$ 3) ______

A) 6 B) 8 C) 2 D) 9

**Solve the problem by finding and evaluating an appropriate expression.**

4) Diane bought a sofa by paying $210 down and $25 per month for 36 months. Find the total cost. 4) ______

A) $271 B) $1110 C) $1320 D) $8460

**Evaluate the polynomial.**

5) $-10x^2 + 10x + 2$ for $x = 2$ 5) ______

A) -28 B) 2 C) -18 D) -22

**Add.**

6) $(3a^4 + 4a^3) + (7a^4 - 9a^3)$ 6) ______

A) $5a^{14}$ B) $10a^4 - 5a^3$ C) $5a^7$ D) $10a^8 - 5a^6$

**Subtract.**

7) $(9n^7 + 14n^4 + 3) - (-10n^4 + 7n^7 + 11)$ 7) ______

A) $2n^7 + 24n^4 - 8$ B) $2n^7 + 24n^4 + 14$ C) $2n^7 + 21n^4 + 14$ D) $18n^{11}$

**Write with positive exponents only.**

8) $\frac{(x^{-5})^3}{x^3x^2}$ 8) ______

A) $x^{20}$ B) $x^7$ C) $\frac{1}{x^{20}}$ D) $\frac{1}{x^7}$

9) $\frac{(x^4y^{-2})^4}{x^{-4}y^4}$ 9) ______

A) $\frac{x^{20}}{y^{12}}$ B) $\frac{y^{16}}{x^8}$ C) $\frac{y^{20}}{x^{12}}$ D) $\frac{x^{16}}{y^8}$

**Find the quotient.**

10) $\frac{48x^5 + 24x^3 + 18x^7}{6x^5}$ 10) ______

A) $3x^2 + 8 + \frac{4}{x}$ B) $3x + 8 + \frac{4}{x^2}$ C) $3x^2 + 8 + \frac{4}{x^2}$ D) $3x + 8 + \frac{4}{x}$

11) $\frac{21x^7 + 18x^5 - 24x^2}{-3x^2}$ 11) ______

A) $-7x^7 - 6x^5 + 8x^2$ B) $-7x^5 + 18x^5 - 24x^2$
C) $21x^5 + 18x^3 - 24$ D) $-7x^5 - 6x^3 + 8$

**Solve.**

12) $34 = 6x - 8$ 12) ______

A) $x = 36$ B) $x = 13$ C) $x = 7$ D) $x = 40$

13) $9r + 7 = 97$ 13) ______

A) $r = 10$ B) $r = 3$ C) $r = 81$ D) $r = 85$

14) $3(2z - 5) = 5(z + 4)$ 14) ______

A) $z = 8$ B) $z = 5$ C) $z = 35$ D) $z = -5$

15) $9x - (5x - 1) = 2$ 15) ______

A) $x = -\frac{1}{4}$ B) $x = -\frac{1}{14}$ C) $x = \frac{1}{14}$ D) $x = \frac{1}{4}$

**Solve the formula for the indicated variable.**

16) $A = \frac{1}{2}bh$ for b 16) ______

A) $b = \frac{h}{2A}$ B) $b = \frac{A}{2h}$ C) $b = \frac{Ah}{2}$ D) $b = \frac{2A}{h}$

17) $a + b = s + r$ for s 17) ______

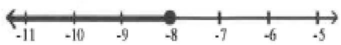
A) $s = \frac{a}{r} + b$ B) $s = a + b - r$ C) $s = \frac{a + b}{r}$ D) $s = r(a + b)$

**Solve using the addition principle. Then graph.**

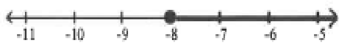
18) $f - 4 < -12$ 18) ______



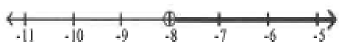
A) $f \le -8$



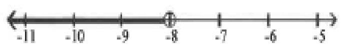

B) $f \ge -8$




C) $f > -8$




D) $f < -8$




**Simplify using scientific notation. Express the answer in standard notation.**

19) $\dfrac{9.03 \times 10^{-5}}{3 \times 10^{-3}}$ 19) ______

A) .00000003 B) .0301 C) .0602 D) .000000064

**Solve by using the addition and multiplication properties of inequalities.**

20) $-4s + 9 \ge -11$ 20) ______

A) $s \ge 5$ B) $s \le 5$ C) $s \le \dfrac{1}{2}$ D) $s \ge 1$

**Solve the equation.**

21) $\dfrac{5}{m} + \dfrac{5}{6} = 1$ 21) ______

A) $m = 10$ B) $m = \dfrac{5}{3}$ C) $m = 30$ D) $m = 6$

22) $\dfrac{2}{m} = \dfrac{m}{2m + 6}$ 22) ______

A) $m = 0$ or $m = \dfrac{-6}{2}$ B) $m = 0$ or $m = 36$

C) $m = -2$ or $m = 6$ D) $\varnothing$

**Solve.**

23) 40% of 300 is what number? 23) ______

A) 12 B) 120 C) 1200 D) 1.2

**Simplify by using the order of operations.**

24) $7 \cdot 6 - 2 \cdot 5 + 9 \cdot 4$ 24) ______

A) −78 B) 68 C) −68 D) 78

**Simplify.**

25) $240 \div 8 - (2 + 1)$ 25) ______

A) 29 B) 28 C) 48 D) 27

Appendix E

Mathematics Post-test

Student: ________________________________________ date: / /

Prof. Sagna Bakary

Postest

**Multiply and simplify. Assume that all variables represent positive real numbers.**

1) $\sqrt{3}(\sqrt{75} + \sqrt{15})$ 1) _______

A) $15 + 3\sqrt{5}$ B) $225 + 3\sqrt{5}$ C) $30$ D) $15 + 9\sqrt{5}$

**Combine the following, if possible.**

2) $-4\sqrt{3} - 6\sqrt{3}$ 2) _______

A) $-10\sqrt{3}$ B) $2\sqrt{3}$ C) $-10\sqrt{6}$ D) $24\sqrt{6}$

**Simplify. Be sure to rationalize all denominators. Assume that all variables represent positive real numbers.**

3) $\frac{\sqrt{150}}{\sqrt{6}}$ 3) _______

A) $5$ B) $6$ C) $5\sqrt{6}$ D) $\frac{5}{\sqrt{6}}$

**Multiply.**

4) $(3x^3y)(-10x^6y^5)$ 4) _______

A) $-30x^9y^6$ B) $-30x^{18}y^5$ C) $-30x^9y^5$ D) $30x^9y^5$

**Simplify. Express your answer with positive exponents. Assume that all variables are nonzero.**

5) $x^{-7} \cdot x^3$ 5) ______

A) $-\frac{1}{x^4}$ B) $\frac{1}{x^4}$ C) $-x^4$ D) $x^4$

**Subtract the polynomials.**

6) $(-3x - 20) - (14x + 2)$ 6) ______

A) $11x - 18$ B) $-17x - 22$ C) $-39x^2$ D) $-17x - 18$

**Find the product.**

7) $(y - 6)(y^2 + 6y - 7)$ 7) ______

A) $y^3 + 29y - 42$ B) $y^3 - 12y^2 - 43y + 42$
C) $y^3 + 12y^2 + 43y - 42$ D) $y^3 - 43y + 42$

**Perform the division.**

8) $\frac{8x^7 + 10x^6 + 6x^5}{2x^6}$ 8) ______

A) $4x + 5$ B) $4x + 10x^6 + \frac{3}{x}$ C) $4x + 5 + \frac{3}{x}$ D) $7x + 5$

**Factor the binomial completely.**

9) $49 - x^2y^2$ 9) ______

A) $(7 - xy)^2$ B) $(7 + xy)^2$ C) $(7 - xy)(7 + xy)$ D) prime

**Factor the trinomial completely. If the polynomial cannot be factored, write "prime."**

10) $2x^2 + 2x - 40$ 10) ______

A) $2(x - 4)(x + 5)$ B) $(x - 4)(2x + 10)$ C) $(2x + 8)(x - 5)$ D) $2(x + 4)(x - 5)$

**Factor the polynomial by grouping.**

11) $3x^2 + 5x + 15x + 25$ 11) ______

A) $(3x + 5)(3x + 5)$ B) $(x + 5)(3x + 5)$ C) $(3x + 5)(5x + 3)$ D) prime

**Solve.**

12) The sum of four times a number and three is the same as the difference of twice the number and eleven. Find the number. 12) ______

A) 4 B) 7 C) -17 D) -7

**Solve for x.**

13) $\frac{7x+5}{4} + 1 = -\frac{4x}{7}$ 13) ______

A) $x = -\frac{21}{11}$ B) $x = -\frac{7}{65}$ C) $x = -\frac{63}{65}$ D) $x = \frac{7}{65}$

**Solve the equation. Don't forget to first simplify each side of the equation, if possible.**

14) $2(y - 9) = 3y - 18$ 14) ______

A) -36 B) 18 C) -18 D) 0

**Solve the system of equations by the substitution method.**

15) 15) ______

$$\begin{cases} 4y = x + 72 \\ 5x + 20y = 0 \end{cases}$$

A) (9, -36) B) (-36, 9)

C) infinite number of solutions D) no solution

**Find the value of the variable that satisfies the equation.**

16) $8x - 3 = 21$ 16) ______

A) $x = 3$ B) $x = 16$ C) $x = 20$ D) $x = 5$

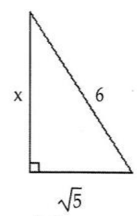
**Using the factoring method, solve for the roots of the quadratic equation.**

17) $24x^2 + 4x = 0$ 17) ______

A) $x = 0, x = 6$ B) $x = 0, x = -6$ C) $x = 0, x = -\frac{1}{6}$ D) $x = 0, x = \frac{1}{6}$

**Find the missing side using the Pythagorean Theorem.**

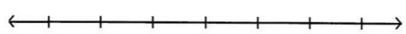
18) 18) ______



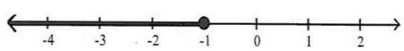

A) $\sqrt{41}$ B) $\sqrt{11}$ C) $\sqrt{31}$ D) 31

**Solve the inequality.**

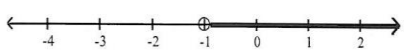
19) $24x + 8 > 4(5x + 1)$ 19) ______



A) $\{x \mid x \le -1\}$




B) $\{x \mid x > -1\}$




C) $\{x \mid x < -1\}$


D) $\{x \mid x \ge -1\}$

**Evaluate.**

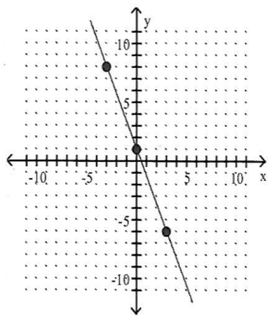
20) $2x^2 - 8xy + 3y^2$ for $x = -5$ and $y = 3$ 20) ______

A) 197 B) 213 C) 117 D) 301

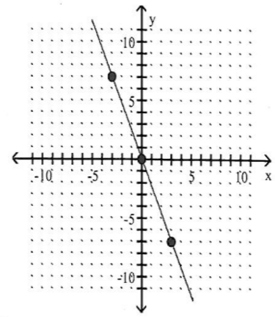
**Complete the ordered pairs for the given linear equation. Then plot the points and graph the equation by connecting the points.**

21) $7x + 3y = 0$ 21) ______

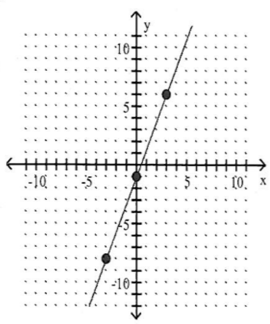
A)



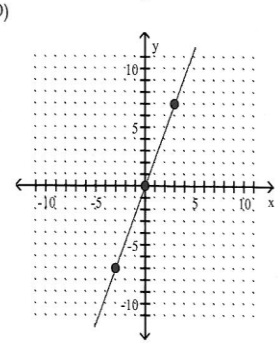

B)




C)




D)




**Write an equation of the line passing through the given points.**

22) (9, 21) and (6, 15) 22) ______

A) $y = 2x + 3$ B) $y = -2x + 39$ C) $y = -\frac{1}{2}x + \frac{51}{2}$ D) $y = \frac{1}{2}x + \frac{33}{2}$

**Find the slope of the line that passes through the points.**

23) (3, 8) and (5, 5)  23) ______

A) $\frac{13}{8}$  B) $-\frac{2}{3}$  C) $\frac{3}{2}$  D) $-\frac{3}{2}$

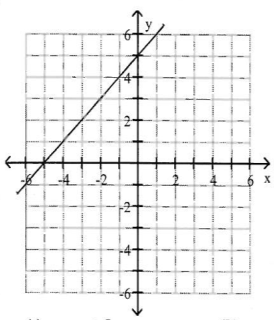
**Find the slope of the line.**

24) $4x + y = 12$  24) ______

A) $m = 4$  B) $m = -\frac{1}{4}$  C) $m = -4$  D) $m = \frac{1}{3}$

**Write an equation in slope-intercept form for the line shown.**

25)  25) ______




A) $y = x + 5$  B) $y = -x - 5$  C) $y = x - 5$  D) $y = -x + 5$

Appendix F

Questionnaire

**Student's ID#: ______________________________________________________**

**Direction:** Please rate each item as to the extent/desire that your mathematics supplemental instructor displayed the following traits and behavior using the following scale and write comment if necessary.

**5: Always    4: Often    3: Sometimes    2: Rarely    1: Never**

| Factors | My Peer-Leader (SI)…. | 5 | 4 | 3 | 2 | 1 | Comments |
|---|---|---|---|---|---|---|---|
| Personality Traits | Has a good relationship with the students. | | | | | | |
| | Has an appealing personality with good sense of humor. | | | | | | |
| Teaching skills | Engages, motivates and maintains students' attentions. | | | | | | |
| | Is organized in presenting solutions. | | | | | | |
| Subject matter | Shows many possible ways to solve a problem | | | | | | |
| | Answers with confidence students' mathematics questions | | | | | | |
| Constructive/Active learning | Creates climate of mutual trust and respect in the classroom. | | | | | | |
| | Ensures students; participation in the learning process. | | | | | | |
| Collaborative learning | Gives constructive feedback. | | | | | | |
| | Allows students to present their solutions to their peers. | | | | | | |
| Effective communication | Uses correct vocabulary and grammar in speaking and writing | | | | | | |
| | Responds to students' questions in appropriate language. | | | | | | |

# Appendix G

## Contents of the City University of New York Assessment Tests (CAT) in Mathematics

*Elementary Algebra:* The Elementary Algebra test, comprised of 12 questions, measures the ability to perform basic algebraic operations and to solve problems involving elementary algebraic concepts. There are three types of Elementary Algebra questions:

**Operations with integers and rational numbers:** Topics include computation with integers and negative rationals, the use of absolute values, and ordering.

**Operations with algebraic expressions:** Topics include the evaluation of simple formulas and expressions, adding and subtracting monomials and polynomials, multiplying and dividing monomials and polynomials, the evaluation of positive rational roots and exponents, simplifying algebraic fractions, and factoring.

**Solution of equations, inequalities, word problems:** Topics include solving linear equations and inequalities, solving quadratic equations by factoring, solving verbal problems presented in an algebraic context (including geometric reasoning and graphing), and the translation of written phrases into algebraic expressions.

*College-Level Mathematics:* The College-Level Math test, comprises 20 questions; it measures the ability to solve problems that involve college-level mathematics concepts. There are five types of College-Level Math questions:

**Algebraic operations:** Topics include simplifying rational algebraic expressions, factoring, expanding polynomials, and manipulating roots and exponents.

**Solutions of equations and inequalities:** Topics include the solution of linear and quadratic equations and inequalities, equation systems, and other algebraic equations.

**Coordinate geometry:** Topics include plane geometry, the coordinate plane, straight lines, conics, sets of points in the plane, and graphs of algebraic functions.

**Applications and other algebra topics:** Topics include complex numbers, series and sequences, determinants, permutations and combinations, fractions and word problems, and functions.

Appendix H

Factor analysis output

**Descriptive Statistics**

| | Mean | Std. Deviation | Analysis N |
|---|---|---|---|
| 1. Has some good relationships with the students | 4.84 | 0.40 | 198 |
| 2. Has an appealing personality with good sense of humor | 4.70 | 0.60 | 198 |
| 3. Has some good relationships with the students | 4.69 | 0.59 | 198 |
| 4. Is organized in presenting solutions | 4.73 | 0.53 | 198 |
| 5. Shows many possible ways to solve a problem | 4.69 | 0.61 | 198 |
| 6. Answers with confidence students' mathematics questions | 4.82 | 0.47 | 198 |
| 7. Creates climate of mutual trust and respect in their classroom | 4.83 | 0.42 | 198 |
| 8. Ensures students participation in the learning process. | 4.73 | 0.57 | 198 |
| 9. Gives constructive feedback. | 4.71 | 0.57 | 198 |
| 10. Allows students to present their solutions to their peers. | 4.78 | 0.44 | 198 |
| 11. Uses correct vocabulary and | 4.83 | 0.42 | 198 |
| 12. Responds to students' | 4.92 | 0.33 | 198 |

**Correlation Matrix[a]**

| | | some | appealing | some | appealing | Shows | Answers | Creates | Ensures | constructiv | students | correct | Responds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Correlation | 1. Has | 1.000 | 0.637 | 0.390 | 0.279 | 0.460 | 0.364 | 0.469 | 0.300 | 0.331 | 0.346 | 0.111 | 0.289 |
| | 2. Has an | 0.637 | 1.000 | 0.544 | 0.382 | 0.500 | 0.314 | 0.416 | 0.291 | 0.231 | 0.242 | 0.095 | 0.289 |
| | 3. Has | 0.390 | 0.544 | 1.000 | 0.643 | 0.629 | 0.444 | 0.378 | 0.229 | 0.243 | 0.278 | 0.235 | 0.318 |
| | 4. Is | 0.279 | 0.382 | 0.643 | 1.000 | 0.716 | 0.570 | 0.230 | 0.128 | 0.248 | 0.245 | 0.183 | 0.260 |
| | 5. | 0.460 | 0.500 | 0.629 | 0.716 | 1.000 | 0.572 | 0.406 | 0.283 | 0.353 | 0.271 | 0.130 | 0.282 |
| | 6. | 0.364 | 0.314 | 0.444 | 0.570 | 0.572 | 1.000 | 0.312 | 0.143 | 0.512 | 0.327 | 0.157 | 0.240 |
| | 7. | 0.469 | 0.416 | 0.378 | 0.230 | 0.406 | 0.312 | 1.000 | 0.570 | 0.365 | 0.480 | 0.383 | 0.628 |
| | 8. | 0.300 | 0.291 | 0.229 | 0.128 | 0.283 | 0.143 | 0.570 | 1.000 | 0.289 | 0.427 | 0.424 | 0.589 |
| | 9. Gives | 0.331 | 0.231 | 0.243 | 0.248 | 0.353 | 0.512 | 0.365 | 0.289 | 1.000 | 0.369 | 0.175 | 0.311 |
| | 10. Allows | 0.346 | 0.242 | 0.278 | 0.245 | 0.271 | 0.327 | 0.480 | 0.427 | 0.369 | 1.000 | 0.427 | 0.438 |
| | 11. Uses | 0.111 | 0.095 | 0.235 | 0.183 | 0.130 | 0.157 | 0.383 | 0.424 | 0.175 | 0.427 | 1.000 | 0.491 |
| | 12. | 0.289 | 0.289 | 0.318 | 0.260 | 0.282 | 0.240 | 0.628 | 0.589 | 0.311 | 0.438 | 0.491 | 1.000 |
| Sig. (1-tailed) | 1. Has | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.060 | 0.000 |
| | 2. Has an | 0.000 | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.092 | 0.000 |
| | 3. Has | 0.000 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 4. Has an | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 | 0.001 | 0.036 | 0.000 | 0.000 | 0.005 | 0.000 |
| | 5. | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.034 | 0.000 |
| | 6. | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | 0.022 | 0.000 | 0.000 | 0.014 | 0.000 |
| | 7. | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8. | 0.000 | 0.000 | 0.001 | 0.036 | 0.000 | 0.022 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.000 |
| | 9. Gives | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | 0.007 | 0.000 |
| | 10. Allows | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 |
| | 11. Uses | 0.060 | 0.092 | 0.000 | 0.005 | 0.034 | 0.014 | 0.000 | 0.000 | 0.007 | 0.000 | | 0.000 |
| | 12. | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | |

a. Determinant = .004

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling | | 0.850 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1075.321 |
| | df | 66 |
| | Sig. | 0.000 |

**Communalities**

| | Initial | Extraction |
|---|---|---|
| 1. Has some good relationships with the students | 1.000 | 0.717 |
| 2. Has an appealing personality with good sense of humor | 1.000 | 0.793 |
| 3. Has some good relationships with the students | 1.000 | 0.627 |
| 4. Is organized in presenting solutions | 1.000 | 0.761 |
| 5. Shows many possible ways to solve a problem | 1.000 | 0.752 |
| 6. Answers with confidence students' mathematics questions | 1.000 | 0.689 |
| 7. Creates climate of mutual trust and respect in their classroom | 1.000 | 0.701 |
| 8. Ensures students participation in the learning process. | 1.000 | 0.657 |
| 9. Gives constructive feedback. | 1.000 | 0.384 |
| 10. Allows students to present their solutions to their peers. | 1.000 | 0.529 |
| 11. Uses correct vocabulary and grammar in speaking and writing | 1.000 | 0.598 |
| 12. Responds to students' questions in appropriate language. | 1.000 | 0.672 |

Extraction Method: Principal Component Analysis.

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Loadings | | | Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 4.990 | 41.583 | 41.583 | 4.990 | 41.583 | 41.583 | 2.954 | 24.620 | 24.620 |
| 2 | 1.825 | 15.210 | 56.793 | 1.825 | 15.210 | 56.793 | 2.872 | 23.932 | 48.553 |
| 3 | 1.063 | 8.861 | 65.654 | 1.063 | 8.861 | 65.654 | 2.052 | 17.102 | 65.654 |
| 4 | 0.958 | 7.984 | 73.638 | | | | | | |
| 5 | 0.632 | 5.265 | 78.903 | | | | | | |
| 6 | 0.497 | 4.143 | 83.045 | | | | | | |
| 7 | 0.439 | 3.659 | 86.704 | | | | | | |
| 8 | 0.419 | 3.488 | 90.193 | | | | | | |
| 9 | 0.357 | 2.975 | 93.168 | | | | | | |
| 10 | 0.327 | 2.725 | 95.893 | | | | | | |
| 11 | 0.283 | 2.359 | 98.251 | | | | | | |
| 12 | 0.210 | 1.749 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

| Component Matrix[a] | | | |
|---|---|---|---|
| | Component | | |
| | 1 | 2 | 3 |
| 5. Shows many possible ways to solve a problem | 0.748 | -0.433 | |
| 7. Creates climate of mutual trust and respect in their classroom | 0.734 | 0.357 | |
| 3. Has some good relationships with the students | 0.708 | -0.355 | |
| 12. Responds to students' questions in appropriate language. | 0.657 | 0.490 | |
| 2. Has an appealing personality with good sense of humor | 0.656 | | -0.549 |
| 1. Has some good relationships with the students | 0.656 | | -0.520 |
| 6. Answers with confidence students' mathematics questions | 0.649 | -0.359 | 0.373 |
| 4. Is organized in presenting solutions | 0.648 | -0.493 | 0.315 |
| 10. Allows students to present their solutions to their peers. | 0.615 | 0.353 | |
| 8. Ensures students participation in the learning process. | 0.592 | 0.538 | |
| 9. Gives constructive feedback. | 0.563 | | |
| 11. Uses correct vocabulary and grammar in speaking and writing | 0.460 | 0.529 | 0.326 |

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

**Rotated Component Matrix[a]**

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| 12. Responds to students' questions in appropriate language. | 0.783 | | |
| 8. Ensures students participation in the learning process. | 0.755 | | |
| 11. Uses correct vocabulary and grammar in speaking and writing | 0.745 | | |
| 7. Creates climate of mutual trust and respect in their classroom | 0.690 | | 0.449 |
| 10. Allows students to present their solutions to their peers. | 0.673 | | |
| 4. Is organized in presenting solutions | | 0.857 | |
| 6. Answers with confidence students' mathematics questions | | 0.808 | |
| 5. Shows many possible ways to solve a problem | | 0.758 | 0.402 |
| 3. Has some good relationships with the students | | 0.658 | 0.414 |
| 9. Gives constructive feedback. | 0.399 | 0.470 | |
| 2. Has an appealing personality with good sense of humor | | | 0.838 |
| 1. Has some good relationships with the students | | | 0.790 |

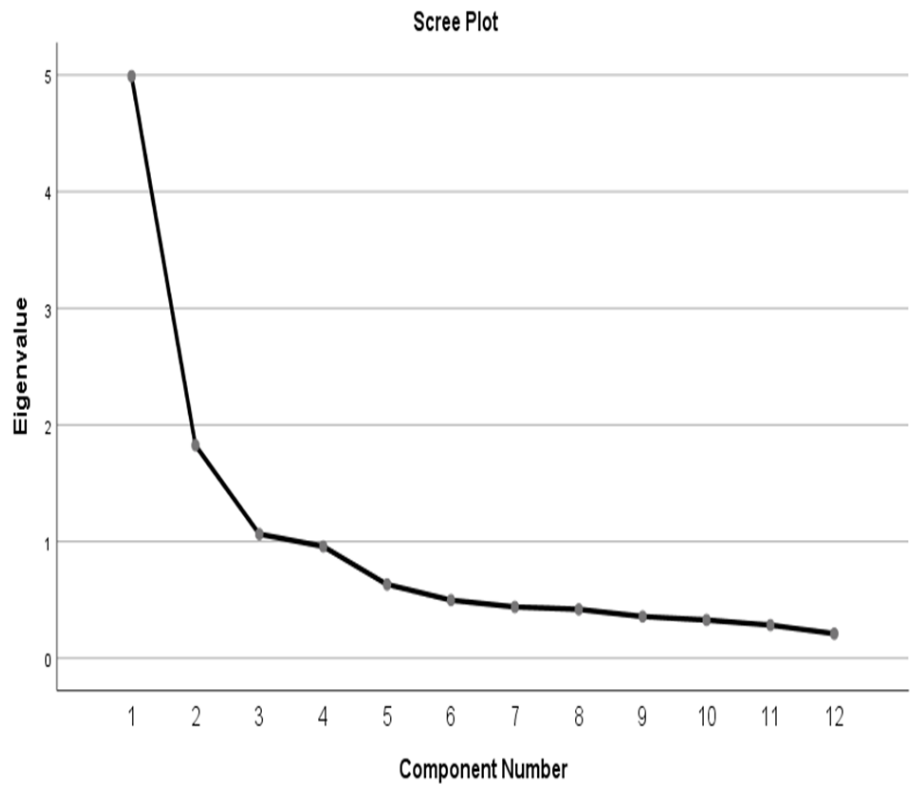
Extraction Method: Principal Component Analysis.

a. Rotation converged in 5 iterations.

**Component Transformation Matrix**

| Component | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 0.603 | 0.626 | 0.494 |
| 2 | 0.779 | -0.596 | -0.196 |
| 3 | 0.171 | 0.504 | -0.847 |

Extraction Method: Principal Component Analysis.


Scree Plot
Eigenvalue
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
Component Number

Appendix I

Multiple linear regression diagnostic test

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Posttest | 71.2323 | 20.13701 | 198 |
| Pretest | 71.0455 | 18.15313 | 198 |
| F1 | 4.9697 | .19921 | 198 |
| F2 | 4.9192 | .27323 | 198 |
| F3 | 4.7374 | .51546 | 198 |

**Correlations**

| | | Posttest | Pretest | F1 | F2 | F6 |
|---|---|---|---|---|---|---|
| Pearson Correlation | Posttest | 1.000 | .424 | .029 | .039 | -.016 |
| | Pretest | .424 | 1.000 | -.034 | -.030 | .078 |
| | F1 | -.016 | .078 | .328 | .268 | 1.000 |
| | F2 | .029 | -.034 | 1.000 | .245 | .328 |
| | F3 | .039 | -.030 | .245 | 1.000 | .268 |
| Sig. (1-tailed) | Posttest | . | .000 | .341 | .292 | .412 |
| | Pretest | .000 | . | .317 | .339 | .139 |
| | F1 | .412 | .139 | .000 | .000 | . |
| | F2 | .341 | .317 | . | .000 | .000 |
| | F3 | .292 | .339 | .000 | . | .000 |
| N | Posttest | 198 | 198 | 198 | 198 | 198 |
| | Pretest | 198 | 198 | 198 | 198 | 198 |
| | F1 | 198 | 198 | 198 | 198 | 198 |
| | F2 | 198 | 198 | 198 | 198 | 198 |
| | F3 | 198 | 198 | 198 | 198 | 198 |

**Variables Entered/Removed**[a]

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | Pretest | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |

a. Dependent Variable: Posttest

**Model Summary**[b]

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .424[a] | .180 | .176 | 18.28257 |

a. Predictors: (Constant), Pretest

b. Dependent Variable: Posttest

**ANOVA**[a]

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 14369.833 | 1 | 14369.833 | 42.991 | .000[b] |
| | Residual | 65513.480 | 196 | 334.252 | | |
| | Total | 79883.313 | 197 | | | |

a. Dependent Variable: Posttest

b. Predictors: (Constant), Pretest

**Collinearity Diagnostics[a]**

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions (Constant) | Pretest |
|---|---|---|---|---|---|
| 1 | 1 | 1.969 | 1.000 | .02 | .02 |
| | 2 | .031 | 7.973 | .98 | .98 |

a. Dependent Variable: Posttest

**Residuals Statistics[a]**

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | 45.3345 | 84.8549 | 71.2323 | 8.54069 | 198 |
| Residual | -48.85670 | 31.84443 | .00000 | 18.23611 | 198 |
| Std. Predicted Value | -3.032 | 1.595 | .000 | 1.000 | 198 |
| Std. Residual | -2.672 | 1.742 | .000 | .997 | 198 |

a. Dependent Variable: Posttest

**Excluded Variables[a]**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics Tolerance | VIF | Minimum Tolerance |
|---|---|---|---|---|---|---|---|---|
| 1 | F1 | -.049[b] | -.757 | .450 | -.054 | .994 | 1.006 | .994 |
| | F2 | .044[b] | .675 | .500 | .048 | .999 | 1.001 | .999 |
| | F3 | .052[b] | .799 | .425 | .057 | .999 | 1.001 | .999 |

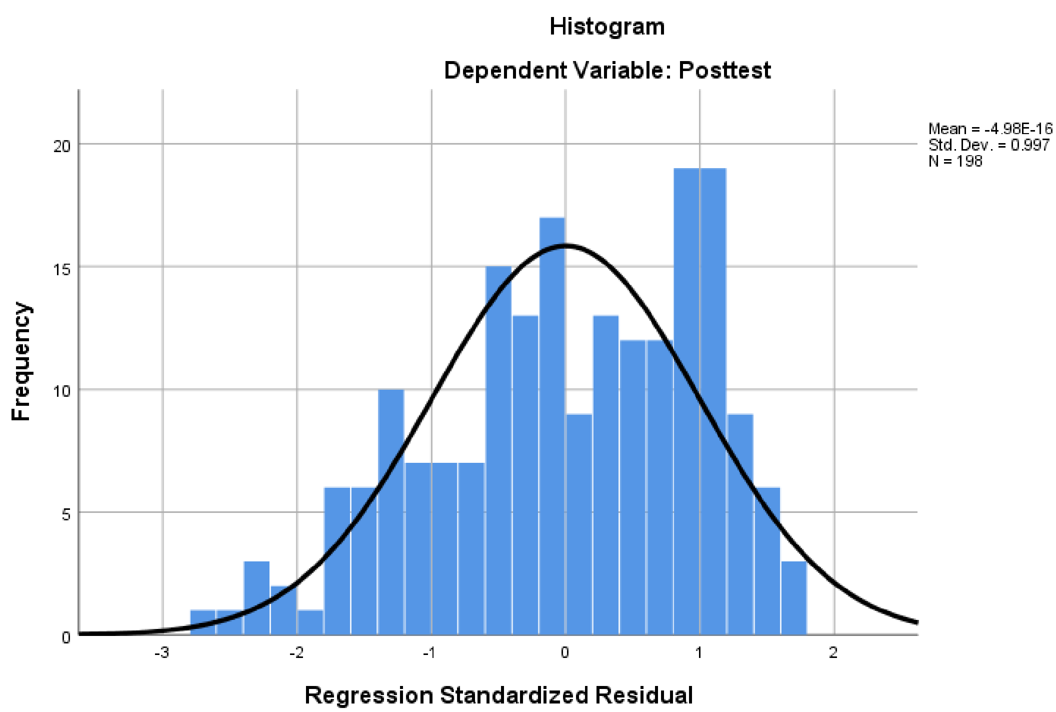
a. Dependent Variable: Posttest

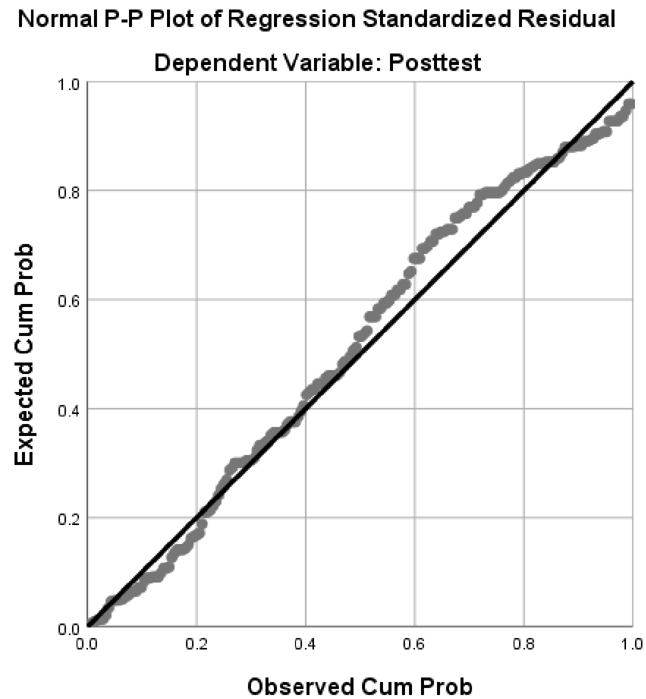
b. Predictors in the Model: (Constant), Pretest

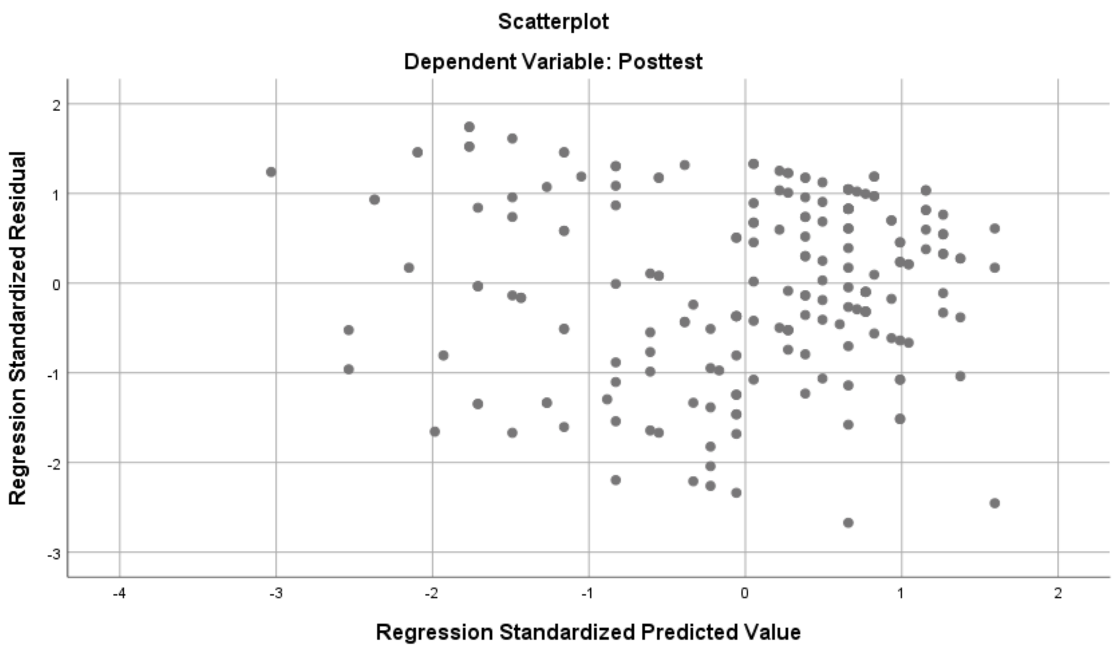
**Coefficients**[a]

| Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. | 95.0% Confidence Interval for B Lower Bound | 95.0% Confidence Interval for B Upper Bound | Correlations Zero-order | Correlations Partial | Correlations Part | Collinearity Statistics Tolerance | Collinearity Statistics VIF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | (Constant) | 37.807 | 5.261 | | 7.186 | .000 | 27.432 | 48.182 | | | | | |
| | Pretest | .470 | .072 | .424 | 6.557 | .000 | .329 | .612 | .424 | .424 | .424 | 1.000 | 1.000 |

a. Dependent Variable: Posttest




Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Posttest
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0


Scatterplot
Dependent Variable: Posttest
Regression Standardized Residual
Regression Standardized Predicted Value
-4
-3
-2
-1
0
1
2