THE EFFECTIVENESS OF SUPPLEMENTAL INSTRUCTION AND ONLINE HOMEWORK IN FIRST-SEMESTER CALCULUS

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ABSTRACT

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The purpose of this study was to evaluate whether supplemental instruction and online homework can improve student performance and understanding in a first-semester calculus course at a large urban four-year college. The study examined the metacognitive and study skills and posttest scores of students. The study also focused on students' and instructor's perception and experiences of supplemental instruction and online homework using WebAssign.

The study used a modified version of the Motivated Strategies for Learning Questionnaire (MSLQ) to reveal any significant differences in metacognitive and study strategies between students in a class with supplemental instruction/online homework and

students in a traditional class. Students' scores on their final examination were analyzed to reveal the effect of mathematical achievement between the control and experimental groups. Surveys and interviews were utilized to provide anecdotal evidence as to the overall effectiveness of the online homework management system and supplemental instruction.

Results of the study showed no substantial difference between the control group and the experimental group in seven out of eight sub-scales of metacognitive and study strategies: metacognitive self-regulation, time and study environment, effort regulation, help seeking, rehearsal, organization, and critical thinking. But, students with supplemental instruction/online homework showed a higher level of elaboration learning strategies. The interaction of pretest and type of class (traditional or treatment) did not have a significant effect on students' posttest score. There was no substantial effect of pretest on posttest, but the treatment influenced students' posttest score. Students' gender, race, class level, or the number of courses they registered for were insignificant predictors of their posttest scores. The instructor and students agreed that time spent in supplemental instruction sessions and on WebAssign were worthwhile and beneficial. They believed supplemental instruction and online homework using WebAssign may have influenced students' understanding and performance in the course.

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B. R. K.

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INTRODUCTION

Need for the Study

In February 2009, President Obama announced his commitment to ensure that, by 2020, the United States will once again lead the world with the highest proportion of college graduates (Advisory Committee on Student Financial Assistance, 2012; Obama, 2009). The need to improve the performance of U.S. students in science, technology, engineering and mathematics (STEM) is widely recognized (McGivney-Burelle & Xue, 2013; Zerr, 2007). In response to a growing concern that the U.S. is facing a crisis in college attainment rates, many programs in the NYC-Metro area are promoting college access, success, and completion. The Percy Ellis Sutton SEEK program is one such program offered by the City University of New York at its senior (four year) colleges. SEEK provides comprehensive academic support to assist capable students who otherwise might not be able to attend and succeed in college, due to their educational and financial circumstances. Students are admitted into the program without regard to age, sex, sexual orientation, race, disability, or creed.

In addition to the services the college provides to regularly admitted students, SEEK offers an array of instructional, financial, and counseling support services to its students. One benefit of SEEK programs is supplemental instruction hours attached to high-risk academic courses. Supplemental instruction covers all the first-year classes and some upper-level courses. Supplemental Instruction (SI) is a student academic assistance program that may increase student academic performance and retention in high-risk courses (Martin & Arendale, 1992). An evaluation of the effectiveness of supplemental instruction in a first-semester calculus course at one of the senior colleges of the City University of New York should be enlightening to educators and administrators.

Why first-semester calculus? At the college in this study first-semester calculus was recently added to the list of courses being offered with supplemental instruction. Thus, it is the highest upper level mathematics course with supplemental instruction and the most recently included. A budget cut may result in a reduction of any supplemental hours attached to this course. Calculus, as a prerequisite for many STEM disciplines, is a crucial course. Despite its importance, it is also a high-risk course. High-risk courses can be defined as those traditionally difficult academic courses that have a 30% or higher rate of D or F final course grades and/or withdrawals (Blanc, DeBuhr, & Martin, 1983; Kenney, 1988; Martin & Arendale, 1992; Peacock, 2008).

Regardless of the numerous efforts over the past decades to modify the teaching and learning of first-semester calculus, this course remains a filter for STEM majors (McGivney-Burelle & Xue, 2013). The 2010 College Board reported that during a single semester, 325,000 students were enrolled in a first-semester calculus course, with 75% of them intending to major in a STEM discipline. However, 27% of the students received a D or F or withdrew from the course and a further 23% received a C.

A traditional calculus class consists of lectures provided by the instructor and homework completed by the students. During the lecture phrase students may be given time to attempt a problem and get feedback from the instructor or peers. Depending on the feedback, students may revise their solutions. McGivney-Burelle and Xue (2013) observed that in a typical lecture emphasis is placed on the lower levels of the cognitive domains in Bloom's Taxonomy. However, when the students are solving homework questions on their own they are expected to engage in the higher-level skills of analysis, synthesis, and evaluation without the support of their peers and instructor.

Homework is an essential part of learning. Students need the opportunity to practice and apply the concepts and skills demonstrated by their instructors. Many learning theories support this notion. For instance, constructivism theory (Davis, Maher, & Noddings, 1990) and social cognitive theory (Schunk, Pintrich, & Meece, 2008) state that students' practice needs to be followed by instructor feedback in order for students to verify their understanding. For students to receive the maximum benefits of doing homework, they should receive feedback on their attempts.

One promising way to improve the passing rate of first-semester calculus is to provide opportunities for students to receive peer and/or instructor support outside of the traditional lecture. Out-of-class time should be highly structured to best prepare students for in-class activities (McGivney-Burelle & Xue, 2013).

Many studies show that supplemental instruction has helped students to perform at higher levels (Blanc et al., 1983; Boylan, 1997; Congos, 2002; Congos & Stout, 2001; Kenney, 1988; Ning & Downing, 2010; Ogden, Thompson, & Simons, 2003; Peacock, 2008; Rettinger & Palmer, 1996; Wright, Wright, & Lamb, 2002). Additionally, the supplemental instruction model claims to increase students' metacognitive and study skill (Ning & Downing, 2010; Peacock, 2008).

In previous studies (Blanc et al., 1983; Kenney, 1988; Ning & Downing, 2010; Ogden et al., 2003; Peacock, 2008; Wright et al., 2002), supplemental instruction functioned in an out-of-class session where attendance was voluntary on the part of the students. These studies assumed that because of the voluntary nature of the supplemental instruction program, expectations for the students receiving supplemental instruction are the same as for the traditional students, which likely contributes to the success of the SI students (Ogden et al., 2003). Most of the supplemental instruction leaders are peers, tutors, or graduate students who have successfully passed the targeted high-risk course with a grade of A or B (Congos & Stout, 2001; Ning & Downing, 2010; Peacock, 2008; Rettinger & Palmer, 1996).

Online homework is a new alternative to traditional paper-and-pencil homework in the teaching and learning of mathematics. Evidence indicates that online homework can result in an improvement in overall student performance (Bonham, Beichner, & Deardorff, 2001; Bonham, Deardorff, & Beichner, 2003; Brewer & Becker, 2010; Burch & Kuo, 2010; Cheng, Thacker, Cardenas, & Crouch, 2004; El-Labban, 2003; Palocsay & Stevens, 2008; Zerr, 2007). The goal of using online homework management systems is to allow students to complete, submit, and receive immediate feedback on their homework assignments online.

In previous studies (Bonham et al., 2001, 2003; Brewer & Becker, 2010; Burch & Kuo, 2010; Cheng et al., 2004; El-Labban, 2003; Palocsay & Stevens, 2008) the analysis was done using online homework in a non-calculus class. Zerr (2007) studied the impact of online homework in first-semester calculus classes. However, the online homework management system utilized in all these studies differs from the one contemplated for the present study. One study by John Richard Griggs in 2001 examined the effects of homework assignments that are both delivered and submitted via the web using the online homework management system utilized in this study on student achievement in a calculus course.

Purpose of the Study

The purpose of this mixed-methods study is to evaluate whether Supplemental Instruction and Online Homework can improve student performance and understanding in a first-semester calculus course at a large urban four-year college. The following research questions will guide the study:

1. How do the metacognitive and study skills of students in a calculus class with supplemental instruction and online homework differ from those of students in a traditional class?
2. Is there a significant difference in the posttest scores between students in a class with supplemental instruction/online homework and students in a traditional class?
3. What are students' and an instructor's perception and experiences of supplemental instruction and online homework?

This study should enable educators and administrators to better understand the impact of supplemental resources on students' mathematical understanding and achievement in a first-semester calculus course. Thus, they can be better able to make informative decisions regarding funding and utilizing supplemental resources in the college in this study.

Procedure of the Study

The study took place at a large urban four-year college in the borough of Queens, America's most ethnically diverse county (Alba, Denton, Leung, & Logan, 1995). The college has students from more than 150 nations.

The study utilized Campbell and Stanley's (1963) Nonequivalent Control Group model because true randomization of the participants in this study could not be achieved. The control group in this study are sections of first-semester calculus with no supplemental instruction and no online homework. The experimental group is sections of first-semester calculus with supplemental instruction and online homework. The students self-enroll in these classes.

Students in the groups were compared on the following independent variables: gender, race, class level, and number of registered courses. This comparison enables the researcher to determine whether there is reasonable equivalence of the groups. According to Orcher (2005), it is important to collect demographic information on all subjects in a study in order to establish the equivalence of the groups.

The Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich, Smith, Garcia, and McKeachie (1991) at the University of Michigan has two sections: motivation and learning strategies. This instrument was selected because of its validity and reliability. Since the study focused on the metacognitive and study skills of students in first-semester calculus, only items in the learning strategies section of the MSLQ were included in the questionnaire used in the study. The modified version of the MSLQ was given to all students in the study near the end of the course to assess their metacognitive and study skills

The modified MSLQ was used to reveal any significant differences in metacognitive and study strategies between students in a class with supplemental instruction/online homework and students in a traditional class. The metacognitive strategies section inquired about students' ability to understand, control, and manipulate their own cognitive processes while the study skills section inquired about students' self-regulation, time and effort management, help-seeking, efficacy and control beliefs (Pintrich et al.,1991).

Responses from the modified MSLQ were analyzed to answer the first research question. The items on the modified MSLQ were scored on a 5-point Likert-type scale with 1 meaning *strongly disagree* and 5 meaning *strongly agree*. There were eight subsections of metacognitive and study strategies in the questionnaire in the study. Each subsection had several items. The ratings on the items in each of the eight subsections were averaged to produce a score for that subsection. An independent samples t-test verified whether there were substantial differences between the control and experimental groups in each of the eight subsections.

Every section of first-semester calculus in the college in this study took a departmental final examination. So, all the students in this study took the same final examination at the end of the semester. Thus, the posttest in this study was the departmental final examination. The results of the final examination were analyzed to reveal the effect of mathematical achievement between the control and experimental groups.

There is no instructor at the college in the study who taught both traditional classes as well as classes with supplemental instruction. As such, there were two instructors in the study. One instructor taught the control group and one instructor taught the experimental group. The posttests were graded by the instructors of each group.

In order to rule out instructor difference, several classroom observations and a comparison of several of the students graded final examination from each instructor were done in an attempt to ensure that their presentation of course material, pedagogical strategy, and grading policy was similar. Three classroom observations for each group were conducted during the 2^{nd}, 5^{th} and 10^{th} week of the course. A comparison of three students from each group with score range 70-75, 80-85 and 90-95 was carried out.

In the study, the control group is further decided into two subgroups: one subgroup took a pretest and one subgroup did not take a pretest. Similarly, there are two experimental subgroups: one subgroup took a pretest and one subgroup did not take a pretest. As such, Solomon four-group design (Solomon, 1949) was used in analyzing the mathematical achievement of students. Table 1 provides an outline of the design of the study. This design guards against threats to internal and external validity (Braver &

Braver, 1988; McGahee & Tingen, 2009). Several types of statistical tests were analyzed to compare the results.

Table 1. *Solomon Four-Group Design of the study*.

Groups	Pretest	Treatment	Posttest
1: Experimental	O_1	X	O_2
2: Control	O_3		O_4
3: Experimental		X	O_5
4: Control			O_6

O = outcome measure; X = treatment

There may exist a relationship between students' posttest score and other independent variables such as their gender, race, class level, and/or the number of registered courses, so a multiple regression model on the experimental group was analyzed as well.

To help gauge students' attitude towards and experience working with supplemental instruction and online homework a survey was distributed near the end of the semester. This survey was distributed to students in the first-semester calculus classes with supplemental instruction and online homework. The responses from this survey were tabulated and analyzed.

Some students from the experimental group were interviewed to determine what worked and/or what did not work for them. These interviews were used to get some feedback on students' perceptions about the use of supplemental instruction/online homework. The interviews were audiotaped and transcribed, and then common themes were identified and coded for analysis.

The instructor who taught the experimental group in this study was interviewed to get her feedback on the use of supplemental instruction and online homework. The interview was audiotaped and transcribed, and then coded for analysis

Surveys and interviews were conducted in order to provide data for a qualitative analysis. Responses from the survey and from instructor's and students' interviews were analyzed to answer the third research question. The surveys and interviews also provided anecdotal evidence as to the overall effectiveness of the online homework management system and supplemental instruction.

Chapter II

LITERATURE REVIEW

Chapter II provides a comprehensive review of the literature related to this study. After introductory remarks, we explored different academic assistant options available to students in college, focused on a particular supplemental instruction system, Martin's supplemental instruction program, examined assessment and online homework systems in general, and then focused on the homework system WebAssign.

Introduction

College graduates need skills to prepare them for the technologically-based jobs of today. The need to improve the performance of U.S. students in science, technology, engineering, and mathematics (STEM) is widely recognized (McGivney-Burelle & Xue, 2013; Zerr, 2007). The report *Tapping America's Potential: The Education for Innovation Initiative* noted that America has decreasing leverage in science, technology, mathematics, and engineering (Walters, 2005). Thus, colleges need to create undergraduate retention programs that will produce more mathematics, science, and engineering majors.

Calculus, as a prerequisite for many STEM disciplines, is a crucial course. Despite its importance, it is also a high-risk course. High-risk courses can be defined as those traditionally difficult academic courses that have a 30% or higher rate of D or F final course grades and/or withdrawals (Blanc et al., 1983; Kenney, 1988; Martin & Arendale, 1992; Peacock, 2008). Regardless of the numerous efforts over the past decades to modify the teaching and learning of first-semester calculus, this course remains a filter for STEM majors (McGivney-Burelle & Xue, 2013).

Astin's Theory of Involvement supports the idea that the more students are involved in their own education, then the more they will learn, the more satisfied they will be with their education, and the more likely it will be that they achieve their educational goals (Astin, 1996). Glover (1996) explored the role of effort in determining students' success in developmental algebra (in Thomas & Higbee, 2000). Her research asked students about attending instructors' office hours, asking questions during and after class, taking notes, working with other students outside of class, studying examples in the text, doing homework, and seeking assistance. She found that each of these behaviors had a significant and direct effect on students' course grade.

Homework is an essential part of learning. Students need the opportunity to practice and apply the concepts and skills demonstrated by their instructors. Many learning theories support this notion. For instance, constructivism theory (Davis, Maher, & Noddings, 1990) and social cognitive theory (Schunk, Pintrich, & Meece, 2008) state that students practice needs to be followed by instructor feedback in order for students to verify their understanding. One promising way to improve the passing rate in first-semester calculus is to provide opportunities for students to receive peer and instructor support outside of the traditional lecture.

Student Academic Assistance Programs

Colleges provide academic assistance to students to combat the daily challenges they face. Some academic assistance programs are customized to attempt to meet the needs of their students. Some academic assistance programs available to students are general-purpose tutoring centers, specific course tutoring centers, break-out sessions for large classes, peer tutoring, supplemental instruction, distance tutoring, help/support via an online platform, and videos.

The general-purpose tutoring centers serve students who need help with any course, computer-assisted learning, assessment, advisement, and/or counseling, whereas the specific course tutoring centers are geared to help students in a specific course only. The services provided to students in these tutoring centers are on a one-on-one basis, ignoring the recommendation for collaborative learning (Boylan, 2002). The tutoring centers' services tend to be reactive in nature instead of proactive. Students generally seek out this type of learning assistance, either at the college tutoring centers where it is free or privately which is not free, after they have a failing grade.

Students most often choose tutorial assistance when they need help. In tutoring sessions, the mathematics tutor tends to reteach the concept, giving answers or solving problem(s) for students, thus depriving them the opportunity to develop their own problem-solving skills (MacDonald, 1993). Too often, tutoring sessions are focused on getting the correct answers only and not on the process being used.

Another type of academic assistance program involves break-out sections for large classes. Such programs are primarily used in universities where the class size can exceed 400 students (Spencer, 1992). Typically, there is a professor for the main lecture and graduate students for the break-out sections, which have about 30 students each. The large lecture sections were instituted to save money, but high failure rates forced the universities to form the break-out sections.

Peer tutoring is another type of academic assistance program. Such programs use peer tutors who are trained and certified. For example, a peer with excellent mathematics skills is assigned to tutor a student who is in need of help with mathematics. The peer tutors are trained to shift the responsibility for learning to the student (Xu, Hartman, Uribe, & Mencke, 2001). Peer tutoring aims to improve academic self-efficacy and college persistence. This type of academic assistance program is also reactive in nature since its primary goal is assisting weaker students to improve (Xu et al., 2001).

One particular form of peer tutoring is an academic assistance program created by Deanna Martin (at the University of Missouri at Kansas City in the mid-1970's) and given the name Supplemental Instruction (SI). Supplemental Instruction is a proactive model where the peer tutor, called the supplemental instruction leader, would attend all classes, and then hold tutoring sessions outside of class time. Martin felt that the tutor could more effectively assist the students in this manner. Supplemental instruction differs from tutorial program in that it integrates study skills for the course with content.

Martin's Supplemental Instruction Program

Martin's supplemental instruction program is designed to assist students in mastering course content, while simultaneously increasing their competency in the study skills relevant to that course as it progresses (Martin, Blanc, & DeBuhr, 1983). The supplemental instruction sessions, which are conducted outside of class time, are led by peer tutors, called supplemental instruction leaders. Students attend the supplemental instruction sessions on a voluntary basis.

Martin and Arendale (1994) defined the features of Martin's supplemental instruction program that contribute to students' success. The characteristics of such an academic assistance program are as follows:

- Supplemental instruction is proactive rather than reactive; it begins from the first day of classes.
- Supplemental instruction is attached to specific courses.
- Supplemental instruction leaders attend all class sessions.
- Supplemental instruction is not a remedial program.
- Supplemental instruction sessions are designed to promote a high degree of student interaction and mutual support.
- Supplemental instruction provides a way for the course instructor to receive feedback from the students through the supplemental instruction leader.

Such features separate Martin's supplemental instruction program from other academic assistance programs.

The supplemental instruction leader's role is not to re-teach the material covered in class by the professor. During supplemental instruction sessions the supplemental instruction leader enables student interaction on course concepts by posing questions and facilitating discussions. At times, questions asked by students in the session are referred to other students. Supplemental instruction sessions enable students to interact in non-threatening group settings and explore not only the "what" of material but the "why" and "how" as well (Stephens, 1995). Collaborative learning within the session increases students' awareness of their thinking processes, study skills, and reasoning, encourages mutual support of others, boosts students' self-confidence and critical thinking skills, and promotes independence.

The supplemental instruction model is built using Piagetian levels as its theoretical base (Martin et al., 1983). The researchers affirmed that the supplemental instruction program facilitates students thought patterns to transition from concrete to formal operational. However, a slightly different analysis of the supplemental instruction program's basic tenets revealed an interesting connection to cognitive psychology, more specially to the area of metacognition. According to Flavell (1976), metacognition refers to "one's knowledge of one's own cognitive processes" and to the active monitoring and regulation of these processes. The monitoring aspect is best exemplified through the concept of a control system overseeing the mental flow of information.

Metacognition is "thinking about your own thinking" (Schoenfeld, 1987b). It focuses on one's knowledge of his/her own thought process. Schoenfeld (1987b) identifies four classroom techniques that focus on metacognition:

1. Using videotapes
2. Teacher as role model for metacognitive behavior
3. Whole class discussions of problems with teacher serving as control

4. Problem solving in small groups

An instructor is demonstrating his/her thinking when he/she is writing the step-by-step solution of a problem on the board. As such, students develop the skills of showing their solutions in a neat and clean presentation. Students need to be challenged in their courses in order to facilitate the development of metacognition and critical thinking skills.

Researchers (Flavell, 1979; McKeachie, Pintrich, & Lin, 1985; Pressley, Ross, Levin, & Ghattala, 1984) in metacognition contend that a well-developed monitoring system plays an important role in oral communication of information, reading comprehension, writing, language acquisition, attention, memory, problem solving, and other aspects of human learning. These studies were conducted in a college level psychology course; however, investigations in metacognition need not be restricted to the discipline of psychology. Metacognitive strategies could be incorporated into the study of mathematics learning (Burton, 1984; Garofalo & Lester, 1985). The previously mentioned researchers agreed that there is a positive relationship between a well-developed cognitive monitoring system and the use of effective learning strategies.

Many students go to college with study habits which tends to lead to several academic problems. These students believe mathematics is basically the memorization of rules given by the instructor which they recall during a test. They have not developed active learning and study strategies. Brown and Burton (1978) noted that unsuccessful mathematics students have built 12 years of misconceptions and systematic, consistent errors which make the traditional methods of teaching unsuccessful at the college level.

In an attempt to provide assistance to students, several colleges introduced developmental courses to offer skills which are necessary for success in college, such as reading and study skills (Houston, 2017; Stephens, 1995). Study skills necessary for success in one academic area may differ substantially from those in another (Goldman & Warren, 1973). Thus, the need to incorporate study skills for the course with content in supplemental instruction sessions. The supplemental instruction leader, having performed well in the course, shared successful learning strategies and study skills with the students.

The National Council of Teachers of Mathematics, in its professional standards, advocated that producing successful learners required the creation of a learning environment that is different from that practiced in the traditional mathematics classroom (1991). 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.

The search for a learning theory to improve the metacognitive and study skills of students led to the cognitive theory of learning. The cognitive theory has four assumptions: (a) Learning is an active process rather than a passive one; (b) Individuals should think about a problem and reduce ambiguity before they can reach a solution; (c) Motivational drive is intrinsic; and (d) Before a learner can solve a problem, he/she needs to be able to look at the pieces of information that define the problem in different ways (Casazza & Silverman, 1996). In discussing the teaching/learning process, Casazza and Silverman (1996) noted that an effective process increases awareness of one’s own thought processes and encourages the learner to gradually assume the responsibility for learning. Martin's supplemental instruction program was found to increase a student's metacognitive and study skills by making him/her an independent learner (Mid-Atlantic Community College, 2006; Peacock, 2008).

Many studies showed that Martin's supplemental instruction program has helped students to attain higher course grades (Blanc et al., 1983; Boylan, 1997; Congos, 2002; Congos & Stout, 2001; Fayowski, 2006; Fayowski & MacMillan, 2008; Feinn, 2004; Kenney, 1988; Martin & Blanc, 1981; Ning & Downing, 2010; Ogden et al., 2003; Peacock, 2008; Rettinger & Palmer, 1996; Shaya, Petty, & Petty, 1993; Stephens, 1995; Vorozhbit, 2012; Wright et al., 2002). Additionally, such a supplemental instruction model claimed to increase students' metacognitive and study skills (Ning & Downing, 2010; Peacock, 2008).

Martin and Blanc (1981) reported the first longitudinal investigation on the effects of Martin's supplemental instruction program. They found that those students who participated in supplemental instruction sessions for an American history course showed patterns of higher course grades and higher rates of retention in college. Results from other case studies (Fayowski, 2006; Fayowski & MacMillan, 2008; Kenney, 1988; Peacock, 2008; Rettinger & Palmer, 1996; Shaya et al., 1993; Stephens, 1995; Vorozhbit, 2012) indicated similar patterns of success in courses such as calculus for non-majors, business calculus, developmental mathematics, psychology, biology, and chemistry. All these studies had a supplemental instruction leader in the classroom who then followed the students into learning assistance sessions called supplemental instruction sessions. Activities during supplemental instruction sessions focused on note-taking, text-reading, interpretation of lecture material, the need to study daily, and solving practice tests. Stephens (1995) observed that "After one month the initial reluctance of the regular participants had changed. They began to feel more comfortable in asking questions" (p. 62).

Fayowski (2006) and Kenny (1988) assessed the effectiveness of supplemental instruction based on students' final grade in first-year calculus for non-majors and first-semester calculus for business majors respectively. Peacock (2008) evaluated the success of the supplemental instruction model in developmental mathematics using students' final grade in the course. Stephens (1995) examined the effects of supplemental instruction in a second-level development mathematics class after each test during the semester rather than at the end of the course only. Rettinger and Palmer (1996) and Shaya et al. (1993) assessed the effectiveness of supplemental instruction in an introductory psychology course and a basic biology course respectively. These studies showed that students who participated in supplemental instruction sessions earned statistically significant improved final grades.

Feinn's (2004) study was a comparison between two groups of students: one receiving supplemental instruction using Martin's supplemental instruction model and the other group receiving additional assistance from the class instructor. The results showed that supplemental instruction did not differ significantly from teacher assistance with regard to final examination scores. Also, students in supplemental instruction sessions were found to have significantly lower grades than students in teacher assistance sessions.

In addition to the mathematical achievement of students, Peacock's (2008) study also investigated the metacognitive and study skills of developmental mathematics students at Mid-Atlantic Community College. According to the college handbook, the supplemental instruction program was designed to increase a student's metacognitive and study skills by making him/her an independent learner (Mid-Atlantic Community College, 2006). To measure the impact of the supplemental instruction model on student's metacognitive and study skills, Peacock used the subscales (rehearsal, elaboration, organization, metacognition, time and study space, and self-effort) of the Motivated Strategies for Learning Questionnaire (MSLQ). Seventy-eight percent of the scales showed no significant difference between the treatment and control groups. However, the subscales of organization and help-seeking both showed a near significance.

The Motivated Strategies for Learning Questionnaire (MSLQ) is a self-report instrument designed to assess college students' motivational orientations and their use of different learning strategies for a college course (Pintrich et al., 1991). It was created by Paul Pintrich, David Smith, Teresa Garcia, and Wilbert McKeachie from the National Center for Research to Improve Postsecondary Teaching and Learning (NCRIPTAL) and the School of Education at the University of Michigan. The MSLQ has two sections: a motivation section and a learning strategies section. According to Pintrich et al. (1991)

> The motivation section assesses students' goals for a course, their beliefs about their skill to succeed in a course, and their anxiety about tests in a course. The learning strategy section assesses students' use of different cognitive and metacognitive strategies. (p. 3)

The MSLQ is based on a general cognitive view of motivation and learning strategies with the student pictured as an active processor of information whose beliefs mediate the input of instruction (Pintrich et al., 1991). It is mostly used to evaluate the effect of a course on students.

These results suggest that Martin's supplemental instruction model is a program that can affect positively students' achievement in high-risk college courses. Additionally, if students are aware of how they learn and how they control their learning then they can gain metacognitive skills that will last them beyond this course.

Online Homework

Given the high failure rate associated with mathematics courses, many instructors are investigating technology as a possible aid. The adoption of technology in teaching supports the recommendation made by the American Mathematical Society (AMS) First-Year Task Force (as cited in Babaali & Gonzalez, 2015), which urges colleges to "harness the power of technology to improve teaching and learning including the use of technology that grades and presents feedback to students on homework assignments and tests." Additionally, the National Council of Teachers of Mathematics (2011) states:

> Strategic use of technology in the teaching and learning of mathematics is the use of digital and physical tools by students and teachers in thoughtfully designed ways and at carefully determined times so that the capabilities of the technology enhance how students and educators learn, experience, communicate, and do mathematics. Technology must be used in this way in all classrooms to support all students' learning of mathematical concepts and procedures. (p. 1)

Technology is implemented in mathematics courses with the hope that its use will lead to increased student achievement and success. Similarly, it is hoped that online homework will help engage students outside of class, encouraging them to take responsibility for their own learning.

Assessment is an integral part of the learning process in higher education. As such, some means of measuring student knowledge and understanding must be available. It is generally accepted that the purpose of homework, seen as essential to success, is to allow students to practice mathematics, develop problem solving skills, and enhance their knowledge (Cheng et al., 2004; Cooper, Robinson, & Patall, 2006; Smolira, 2008; Vandenbussche, Griffiths, & Scherrer, 2014). Recently, most mathematics textbook publishers are providing an online homework system bundled with their textbooks. As such, many instructors are incorporating online homework into their mathematics courses.

Numerous online homework management systems are available for use in mathematics courses. Each online homework system has different features and assignment settings. From time to time instructors may be required to choose which system to recommend or require for students.

Characteristics of an Effective Online Homework System

Online homework systems allow students to retrieve, complete, submit and receive feedback on homework via their web browsers (Griggs, 2000). Many studies (Babaali & Gonzalez, 2015; Burch & Kuo, 2010; Butler & Zerr, 2005; Griggs, 2000; Locklear, 2012; Zerr, 2007) demonstrate two main characteristics of an effective instructional technology in regard to online homework completion: immediate feedback and the allowing of multiple attempts to answer a question.

Immediate feedback has been found to be an effective component of online homework systems. When a student gets an incorrect answer the online homework system immediately provides feedback to the student, allowing him/her to re-try the question and again receive feedback if an incorrect answer is given. This procedure is similar to what an instructor might do during the problem-solving session of a class. The attempt-feedback-reattempt sequence (Babaali & Gonzalez, 2015; Butler & Zerr, 2005; Zerr, 2007) of the online homework system is potentially useful to students in that it provides guidance towards content mastery and provides feedback even in cases when a teacher is not around to do so (Babaali & Gonzalez, 2015; Burch & Kuo, 2010). Some online homework systems provide detailed and specific feedback to students when an incorrect answer is entered in response to a question.

The second effective characteristic of instructional technology in regard to homework completion is providing the opportunity for students to attempt a question more than once or to attempt similar questions after incorrectly answering a question. Pierce and Stacey (2001) noted that the ability of students to get multiple attempts at a question has a positive psychological effect on them. Their study showed that students are more motivated in situations where they could re-do questions, do similar questions or even re-do an entire homework assignment in order to receive a higher score. The ability to do so led the students to believe they could be successful in the course and increased their engagement with the material (Babaali & Gonzalez, 2015; Butler & Zerr, 2005; Pierce & Stacey, 2001). Thus, these online homework systems provide a new way for students to engage in problem solving.

Although it is widely assumed that doing homework is an important aspect of learning, research offers mixed results as to the effectiveness of online homework. Some evidence indicated that online homework resulted in an improvement in overall student performance (Brewer & Becker, 2010; Burch & Kuo, 2010; Cheng et al., 2004; Zerr, 2007). Other studies (Bonham et al., 2001, 2003; El-Labban, 2003; Griggs, 2001; Palocsay & Stevens, 2008) showed that the students who did online homework performed slightly better on in class tests/examinations, but the difference was not statistically significant.

Many studies (Bonham et al., 2001, 2003; Brewer & Becker, 2010; Burch & Kuo, 2010; Cheng et al., 2004; El-Labban, 2003; Palocsay & Stevens, 2008) have analyzed online homework effectiveness in physics, algebra, chemistry, and business statistics, which are non-calculus courses. Griggs (2001) and Zerr (2007) studied the impact of online homework in first-semester calculus classes. Griggs used analysis of covariance to show that there was no significant difference in final homework averages, test scores, examination scores, test averages, and final averages due to treatment (online homework) between two groups. On the other hand, quantitative evidence in Zerr’s study supports the hypothesis that the online homework system improved student learning.

Many textbook publishers have developed individual online homework systems which are bundled with their textbooks. Griggs (2001) assessed the effectiveness of online homework in calculus among students who complete their homework using WebAssign and pencil-paper. Burch and Kuo (2010) compared the effectiveness, in terms of mathematical achievement, of online homework done using CourseCompass to traditional homework assigned from the textbook. Zerr (2007) assessed the effectiveness of online homework in calculus using Backboard’s assessment capabilities. El-Labban (2003) analyzed the relationship between the OWL (Online Web-based Learning) homework and achievement in chemistry. Bonham et al., (2001, 2003) compared performance in physics among students who completed their homework using either WebAssign or pencil-paper. Cheng et al. (2004) assessed students' understanding of physics concepts among students who completed their homework using WEBCT or pencil-paper. Palocsay and Stevens (2008) compared students' understanding of business statistics concepts among students who completed their homework using ALEKS or pencil-paper.

Although it is widely assumed that doing homework is an important aspect of learning, students will not do homework unless it is graded (Cheng et al., 2004). The literature offers mixed results about the effectiveness of online homework, although studies concluded that online homework is as effective as traditional paper-and-pencil homework or is an improvement over the traditional techniques.

Online Homework System: WebAssign

One of the currently available systems being used for online homework is WebAssign. Founded by John Risley Ph.D., a physics education specialist and professor in the Department of Physics at North Carolina State University (NCSU), WebAssign was piloted in 1997 in several large classes at NCSU. In 1998, WebAssign became commercially available as a hosted subscription service and within a year "it became the standard in online homework and grading throughout the United States" (www.webassign.net). In 2012, WebAssign became an employee-owned benefit company with the stated benefit of education.

WebAssign is an online instructional system used mostly for assessments. It is a versatile, web-based homework service for educators who want to offer expanded learning opportunities to their students (Risley, 1999). It is a fully hosted, web-based service with no software to install or databases to maintain. WebAssign is bundled with the textbook it uses. It is designed to help instructors and students in the teaching and learning environment. Students have to pay to access their assignments on WebAssign.

Features for Instructors. WebAssign has several tools for instructors to use for teaching and assessing their students.

1) Assignments.

WebAssign has numerous exercises, problems, simulations, videos, and tutorials for instructors to choose from in creating an assignment. They can also create their own questions or modify existing questions. Numeric values are randomized so each student receives a slightly different version of the question. They can also decide:

- The number of submission attempts for each student
- The point value of each question and question part
- The type of feedback students receives
- When hints are displayed
- Under what conditions bonus or penalty points are applied
- Whether values should randomize per student, or remain the same for all students
- Whether questions should display in a specific sequence, or randomly scramble
- The due date for the assignments

2) Grading

WebAssign grades each assignment created. Instructors can access the gradebook anytime. It shows students’ performance on questions and topics throughout the course.

3) Courses and Sections

Instructors can reuse the assignments created for other sections of the same course. They can also reuse the assignments in other semesters.

4) Collaboration

Instructors can work together, whether at the same institution or across the country. They can collaborate in creating assignment, replying to extension requests, or sharing resources.

5) Communication

Instructors can email a single student, a group of students, or the entire class at once. Students can also contact their instructors with questions about a specific assignment or problem or request an extension on assignment(s).

6) Secure Testing

The WebAssign LockDown Browser prevents students from doing anything on the computer other than work on an assignment if instructors choose to give timed graded examinations online.

7) Support and Services

Support is available via email, telephone, or face-to-face.

Despite the numerous benefits of using WebAssign there are some drawbacks. It can be time consuming to select or create appropriate questions when making an assignment. It is difficult to tell if the students are doing the assignments by themselves or they are getting help from others.

Features for Students. WebAssign has several characteristics for students to use in mastering the concepts and problem-solving skills demonstrated by their instructors in the classroom.

1) Immediate Feedback

As soon as students click submit to a question WebAssign instantly grades it. This allows the students to be aware of the questions they get incorrect and provide them the opportunity to redo the question or a similar question.

2) Multiple Attempts

Students have multiple attempts to answer a question without being penalized.

3) Help Options

WebAssign has some resources, such as step-by-step videos, practice another version, and master it tutorials, if students need help with an assignment or they need additional practice.

4) My Class Insights

This feature allows students to see the questions and concepts they did well and the ones they may need to spend more time on.

5) Ask Your teacher

When students need help or guidance on an assignment or a specific question they can contact their instructors by using this feature.

6) Self-Study Option

There are questions, quizzes, and tests students can practice which will not be included in their instructor assignment grade. There are also study guides students can utilize.

The online instructional system, WebAssign can simplify the creation and grading of assignments as well as provide a practicable platform for assessment, but its effect on student learning has shown mixed results. WebAssign fosters learning by reinforcement and reward, in conjunction with appropriate cueing and immediate feedback.

Conclusion

The literature reviews a variety of academic assistance programs available to students, but no single technique provides the ultimate solution. Improvement in student achievement is seen through a combination of techniques involving multi-sensory approaches to accommodate learner differences. In general, Martin's supplemental instruction seems to be at least moderately effective in improving and enriching student achievement and study skills for those who are motivated to participate. Although research on the effectiveness of online homework has mixed results, most studies conclude that online homework is as effective as traditional paper-and-pencil homework or is an improvement over the traditional techniques.

Chapter III

METHODOLOGY

This study focused on students in two calculus classes with traditional paper-and-pencil homework and students in two calculus classes offering supplemental instruction and online homework. Those who attended the paper-and-pen classes formed the control group whereas those in the supplemental instruction /online homework classes composed the treatment group. In both groups, there were students who took a pretest (see Appendix A) and students who did not. Some students took a pretest to eliminate the assumption that the pretest is not priming them to perform better on the posttest.

The Setting

The study took place at a large urban four-year college located in the borough of Queens, one of America's most ethnically diverse counties (Alba, Denton, Leung, & Logan, 1995). At its founding in 1937, the college was hailed by the people of the borough as "the college of the future" (College website, 2014-2018). The students come from more than 150 different countries and speak over 110 different languages. The college has an enrollment of approximately 20,000 students in their undergraduate and graduate programs. The average age of students at the college is 22. Seventy percent of undergraduate students attend fulltime while twenty three percent of students work more than twenty hours per week.

The college is consistently ranked among the leading institutions in the nation for the quality of its academic programs and student achievement. It is recognized as one of the most affordable public colleges in the country and offers a first-rate education to talented people of all backgrounds and financial means. Seventy five percent of students graduate without any student loan debt and sixty one percent receive some form of grant or scholarship financial aid.

Academic programs are organized into four divisions, which offer both day and evening courses: Arts and Humanities; Mathematics and the Natural Sciences; the Social Sciences; and Education. This college educates more teachers than any other college in the New York City region. The college's centers and institutes serve students and the larger community by addressing society's most important challenges—including cancer, pollution, and racism—as well as celebrating the borough's many ethnic communities. The college's administration is committed to making the campus a home away from home for its students with over 100 clubs and teams.

The college has 1,285 full-time staff: 606 faculty, 57 graduate assistants, 318 civil service employees, and 304 instructional non-teaching staff. There are 1,605 part-time employees: 1,031 instructional, 69 non-instructional, 409 college assistants, and 96 civil service employees. Of the professors with faculty status, 71.1% of the full-time faculty are tenured or have a Certificate of Continuous Employment (CCE), 24.4% are in tenure-track positions, and 4.5% are non-tenure-track faculty.

The college offers several support programs to help students deal with their academic challenges. One such support program is The Percy Ellis Sutton Search for Education, Elevation and Knowledge (SEEK) program. This higher education opportunity program "allowed thousands of promising students from disadvantaged backgrounds the opportunity to attend college at one of the City University Colleges with the help of state funding," (City University of New York, 2018) was launched by the New York State Legislature in 1966. Many of the students in the Percy Ellis Sutton Search for Education, Elevation and Knowledge program are from economically disadvantaged backgrounds, are the first in their family to attend college, have immigrant parents, and have had inadequate academic preparation for college-level coursework.

Counselors and administrative staff advertised the Percy Ellis Sutton Search for Education, Elevation and Knowledge program at high school open house. They work with high school counselors to encourage qualified students to apply for the program. Students accepted into the program spend six weeks in the summer before first year attending workshops at the college. "It's summer boot camp," says the director of the Percy Ellis Sutton Search for Education, Elevation and Knowledge program at the college in this study.

Students in the Percy Ellis Sutton Search for Education, Elevation and Knowledge program build their own informal learning community with their classmates because they take at least three courses together during the first-semester at college. Free tutoring is available to all students in the program. Students are assigned counselors who help them apply for financial aid and address personal, social, and career issues. These counselors work with the students until they graduate. Supplemental instruction covers all the first-year courses as well as some upper-level courses.

Courses with supplemental instruction have at least one supplemental instruction sessions per week. A supplemental instruction session is not a lecture or re-lecture of the course concepts nor is it a traditional tutoring session. It is “an informal guaranteed study time” (Porte, n.d.) led by a supplemental instruction leader. 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. Supplemental instruction sessions are mandatory for every student in the program to attend. Supplemental instruction sessions start the first week of classes.

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 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.

The Course

First-semester calculus is a prerequisite for many STEM disciplines. Despite its importance it has a high failure rate. Because of its low pass rates and the success of supplemental instruction in other mathematics courses in the college involved in this study, first-semester calculus was recently selected to receive supplemental instruction assistance.

There were only two SEEK sections of first-semester calculus at the college in the study. Each section was scheduled to meet for an extra hour each week. This extra hour of class time was used for supplemental instruction sessions. As such, supplemental instruction is mandatory in the study. During the supplemental instruction sessions, students were given the opportunity to actively engage with their supplemental instruction leader and the course material. Some typical activities in supplemental instruction sessions were reviewing for an upcoming test, solving homework assignments, redoing problems done in lecture, designing study schedules, sharing study and notetaking tips, and test taking strategies. As a result, these students should have developed greater familiarity and comfort with the subject matter. Students also met the supplemental instruction leader outside of class periodically throughout the semester for extra help. The supplemental instruction leader also assisted the instructor and/or students during the problem-solving phase of the lecture.

Due to the advancement of technology, many textbook publishers have developed individual online homework management systems which are bundled with their textbooks. The assigned text for first-semester calculus at the college in the study was

James Stewart's *Calculus: Early Transcendentals*, accompanied by the online homework management system WebAssign.

Several sections of the first-semester calculus course were offered in the fall. Instructors had the freedom to decide whether to use WebAssign.

The Participants

The study utilized Campbell and Stanley's (1963) Nonequivalent Control Group model because true randomization of the participants in the study could not be achieved. The control group in the study consisted of two sections of first-semester calculus with no supplemental instruction and no online homework. The experimental group was two sections of first-semester calculus with supplemental instruction and online homework.

The students self-enrolled in these classes. The control group had an enrollment of 56 students and the experimental group had an enrollment of 56 students.

No instructor at the college in the study taught both traditional classes and classes with supplemental instruction. Only one instructor taught first-semester calculus with supplemental instruction and assigned online homework. Instructors who were teaching first-semester calculus in a traditional setting were invited to participate in the study. The instructors who agreed to be participants and their classes participated in the study. After getting approval from instructors, an explanation of the study was given to their students who were then invited to sign a consent form either agreeing or disagreeing to be a part of the study.

So two instructors participated in the study. One instructor, InstructorCon, taught students in the control group and the other instructor, InstructorExp, taught students in the experimental group. The instructors in the study were 65 year old females who started their teaching careers in the early 1970s. They taught a wide range of mathematics courses during their years of teaching at the college. Both instructors were members of the curriculum committee for developmental mathematics courses at the college in this study.

InstructorCon started teaching at the college in 1972 as an adjunct lecturer on and off. She took time off to care for her family when her nine children were born. She was the principal of a private high school for four years before it closed in 2004, when she returned to the college as an adjunct lecturer. She became a fulltime lecturer in February 2009.

InstructorExp started her teaching career in 1973 as a high school mathematics teacher. She took time off from fulltime teaching to care for her family but did private tutoring in college and high school mathematics. She was also a substitute teacher and taught high school mathematics to adults in night school. InstructorExp began teaching at the college in the study in 1992 as an adjunct lecturer and taught there subsequently without a break. She was an adjunct for 18 years before becoming a fulltime lecturer. In September 2010, she started teaching mathematics to SEEK students.

In order to minimize instructor differences, several classroom observations and a comparison of several of the students' graded final examinations from each instructor were done in an attempt to ensure that their presentations of course material, pedagogical strategies, and grading policies were similar. Three classroom observations for each group were conducted during the 2nd, 5th and 10th week of the course. A comparison of three students from each group with score ranges 70-75, 80-85 and 90-95 were examined.

Instruments and Procedures

Quantitative Data

Students exposed to supplemental instruction and online homework have incorporated all four of the classroom techniques that focus on metacognition which Schoenfeld (1987b) described in chapter II. There are numerous videos with step-by-step solutions on WebAssign while students are actively engage in solving problems and discussing their solutions in supplemental instruction sessions.

In order for students to develop effective study skills they need to be able to assess and describe what they know and what they can learn so the Motivated Strategies for Learning Questionnaire (MSLQ) was used for this study. It has two sections: motivation and learning strategies. The motivation section assesses students' goals and value beliefs for a course, and their anxiety about tests in a course. The learning strategy section assesses students' use of different cognitive and metacognitive strategies, and their management of different resources. This instrument was selected because of its validity and reliability.

This study focused on the metacognitive and study skills of students in first-semester calculus so only items in the learning strategies section of the MSLQ were included in the questionnaire used in the study. A modified version of the MSLQ (see

Appendix B) was given to all students in the study during the 12th week of the course to assess their metacognitive and study skills.

The modified MSLQ was used to reveal any significant differences in metacognitive and study strategies between students in a class with supplemental instruction/online homework and students in a traditional class. The metacognitive strategies section inquired about students' ability to understand, control, and manipulate their own cognitive processes while the study skills section inquired about students' self-regulation, time and effort management, help-seeking, efficacy and control beliefs (Pintrich et al., 1991). Eight subsections of metacognitive and resource management strategies are included in the modified questionnaire. These subsections are:

1. Metacognitive self-regulation refers to the awareness, knowledge, and control of cognition and involves planning, monitoring, and regulating (Pintrich et al., 1991). It measures how often students think about what they are reading, doing, or studying as they solve mathematics problems.
2. Time and study environment strategies involve scheduling, planning, and managing one's study time and the use of a place to study (Pintrich et al., 1991). These include the effective use of study time in a study environment and the setting where the student chose to do her school work.
3. Effort-regulation refers to students' willingness to try hard on their schoolwork, even when the work is difficult (Pintrich et al., 1991). Some mathematics problems can be very long and tedious, so students tend to lose focus and/or give up easily.

4. Help seeking involves students learning to manage the support of others (Pintrich et al., 1991). Students should be aware that there is help outside of the classroom and they should they pursue it.
5. Basic rehearsal strategies involve rereading class notes and course readings and memorizing lists of key words and concepts (Pintrich et al., 1991). These strategies are used to help students retain class notes and course concepts and recall them when needed.
6. Elaboration strategies help students store information into long-term memory by building internal connections between items to be learned (Pintrich et al., 1991). Paraphrasing or summarizing course concepts and connecting new information to what they already know are some elaboration strategies.
7. Organization strategies refers to students' ability to select the main ideas from their readings and organize or put together what they need to learn in the course (Pintrich et al., 1991). Examples of organizing strategies are outlining procedures in solving mathematics problems, selecting main ideas and concepts from readings, and solving problems in a logical and sequential manner.
8. Critical thinking refers to the degree to which students report applying previous knowledge to new situations in order to solve problems, reach decisions, or make critical evaluations with respect to standards of excellence (Pintrich et al., 1991). Critical thinking strategies involve questioning arguments, conclusion, theorems, and other mathematical statements before accepting them as true.

Responses from the modified MSLQ were analyzed using SPSS to answer the first research question. The items on the modified MSLQ are scored on a 5-point Likert-type scale with 1 meaning *strongly disagree* and 5 meaning *strongly agree*. There are eight subsections of metacognitive and study strategies in the questionnaire in the study. Each subsection has a number of items for students to response. The ratings on the items in each of the eight subsections are averaged to produce a score for that subsection. Independent samples t-test verified whether there are substantial differences between the control and experimental groups in each of the eight subsections.

Every section of first-semester calculus in the college in this study took a departmental final examination. So, all the students in this study took the same final examination at the end of the semester. Thus, the posttest (see Appendix C) in this study was the departmental final examination. The results of the final examination were analyzed to reveal the effect of mathematical achievement between the control and experimental groups. The posttests were graded by the instructors of each group. In order to rule out instructor difference, a comparison of several of the students graded final exam from each instructor were done in an attempt to ensure that their grading policy was similar.

In the study, the control group was further divided into two subgroups: one subgroup took a pretest and one subgroup did not take a pretest. Similarly, there were two experimental subgroups: one subgroup took a pretest and one subgroup did not take a pretest. A Solomon four-group design examined the differences in posttest scores among students in the groups. Table 2 (same as Table 1) provided an outline of the design of the study. This design guards against threats to internal and external validity (Braver & Braver, 1988; McGahee & Tingen, 2009).

Table 2. *Solomon Four-Group Design of the Study*

Groups	Pretest	Treatment	Posttest
1: Experimental	O_1	X	O_2
2: Control	O_3		O_4
3: Experimental		X	O_5
4: Control			O_6

O = outcome measure; X = treatment

Several types of statistical tests using SPSS were analyzed to compare the results. According to Campbell and Stanley (1963), the first step in the analysis was to decide if pretest sensitization existed. A 2x2 between-groups analysis of variance (ANOVA) on the four posttest scores was conducted to decide if pretest sensitization existed, as indicated in Table 3. Figure 1 presented a flowchart of tests and conclusions which was carried out during the analysis and interpretation of the findings from the study.

Table 3. *2x2 Analysis of Posttest Scores*

Pretest	Treatment	No treatment
Yes	O_2	O_4
No	O_5	O_6

O = outcome measure

There may exist a relationship between students' posttest scores and other independent variables such as gender, race, class level, and number of registered courses, so a multiple regression model on the experimental group was analyzed. In the multiple regression model, posttest score was the dependent variable and the independent variables were students' gender, race, class level, and the number of courses they registered for.

Attempts were made to determine the equivalency of the control and experimental groups since it was not possible to obtain true control and experimental groups. Students were compared on the following variables: gender, race, class level, and number of registered courses. Orcher (2005) reminded us to collect demographic information on all subjects in a study in order to establish the equivalence of the groups.

Qualitative Data

The qualitative component of the study consisted of surveys and semi structured interviews. The surveys and interviews provided anecdotal evidence as to the overall effectiveness of the online homework management system and supplemental instruction. To help gauge students' attitude towards and experience working with supplemental instruction and online homework, a survey (see Appendix D) created by the researcher was distributed during the 12^{th} week of the course. It consisted of 16 items which ranged in scope from students' familiarity to the benefits of using the online homework system and 13 items which focused on students' experience with supplemental instruction. Responses from the survey are displayed in Appendix G. The Cronbach's alpha (displayed in Table G-1) for the 16 items which focused on online homework was 0.984 and for the 13 items which focused on supplemental instruction was 0.981. The alpha coefficients indicated a high level of internal consistency (reliability) for this sample. Every student in the study answered the survey. However, it is difficult to say if they read and thought the question through before answering.

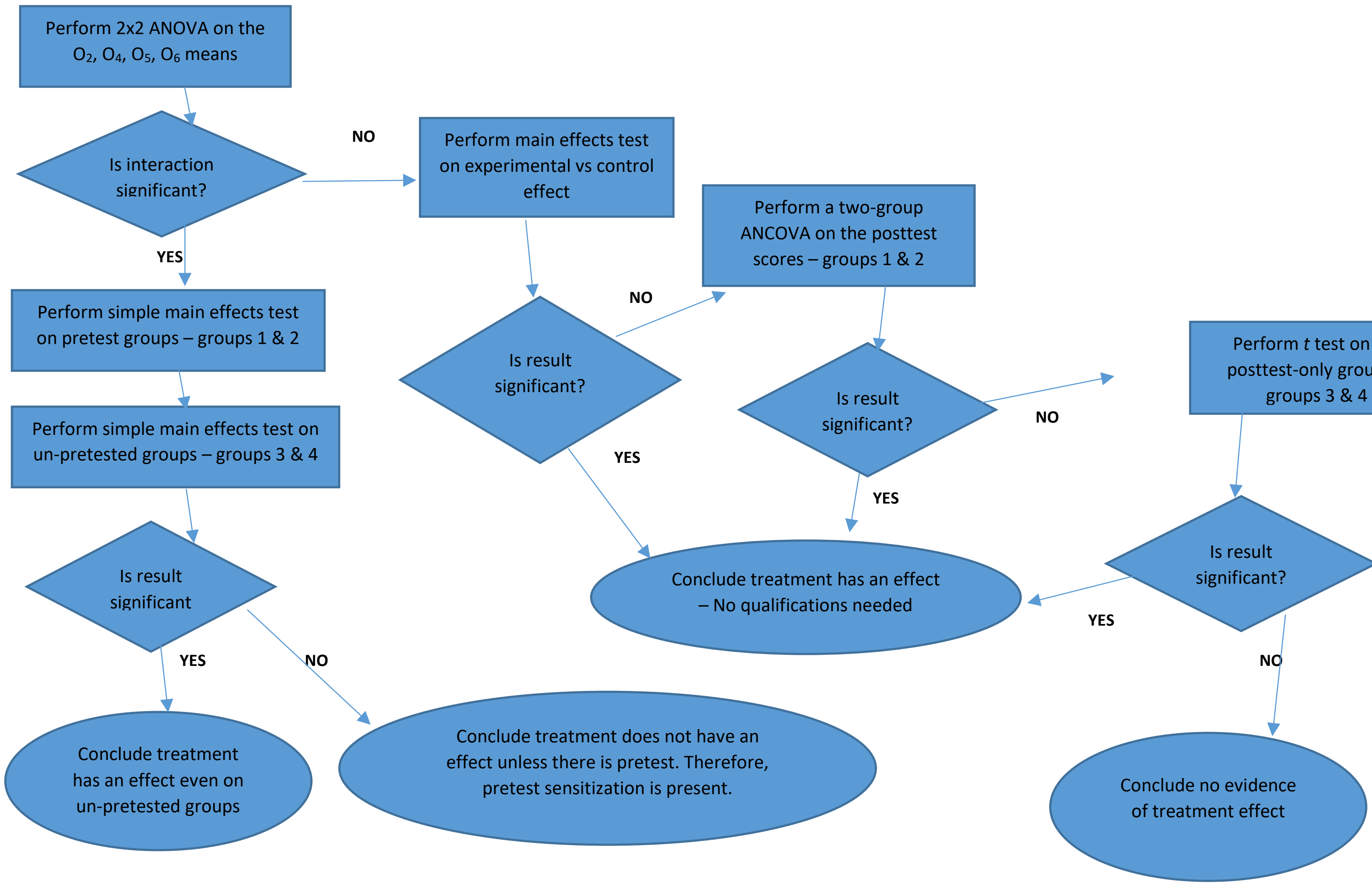

Figure 1. Flowchart of tests and conclusions. (O = outcome measure; ANOVA = analysis of variance; ANCOVA = analysis of covariance.)

Student results established the validity and reliability of the survey. The survey measured what it claimed to measure. Students had to choose the best choice (Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Strongly agree) for each question. The survey was distributed to students in the calculus class with supplemental instruction and online homework. The responses from this survey were tabulated and analyzed to answer the third research question.

Fourteen students from the class with supplemental instruction and online homework were interviewed to determine what works and/or what did not work for them. The ten-minute interviews (see Appendix E) were audiotaped and transcribed then common themes were identified and coded for analysis with regard to the research questions posed. The interviews were conducted to develop an understanding of students' experiences with supplemental instruction and online homework.

The instructor who taught the sections of calculus with supplemental instruction/online homework was interviewed (see Appendix F) to determine her academic and teaching experiences, and to get her feedback on the use of supplemental instruction and online homework. The interview was audiotaped and transcribed, and then coded for analysis.

Institutional Approval and Documentation

The Institutional Review Board (IRB) approval was obtained from Teachers College Columbia University as well as from the college where this study was conducted.

Instructors and students signed the consent and participants’ rights form before the implementation of the study.

Chapter IV

RESULTS AND DISCUSSION

Demographics of Groups

The validation of true group equivalence in the control and experimental groups was not possible due to the lack of students' prior academic records. The demographics of the control and experimental groups are displayed in Table G-2 (Appendix G). All students in the study were between the ages of 18-25 years. The control and experimental groups were equivalent in the demographic variables of age, gender, class level, reason for taking this course and the number of registered courses. Analysis done in SPSS validated the no-difference observations. The results $t(110) = 2.144$, $p = 0.034$, showed that the two groups were significantly different in terms of race. Table 4 shows the race distribution of the students in the study. The control group is 19.6% White/Caucasian compared to 5.4% in the experimental group. Another noticeable difference between the control and experimental groups was among Asians (23.2% vs 41.1%).

Table 4. *Race distribution of students*

Race	Control Group	Experimental Group
White/Caucasian	19.6% (n=11)	5.4% (n=3)
African American	16.1% (n=9)	10.7% (n=6)
Hispanic	26.8% (n=15)	30.4% (n=17)
Asian	23.2% (n=13)	41.1% (n=23)
Other	14.3% (n=8)	12.5% (n=7)

Instructors

Three classroom observations were done throughout the semester. Both instructors began their classes by discussing homework questions which students voluntarily wrote and/or solved on the whiteboard. Following the explanation of new mathematical concepts or rules, students had the opportunity to solve some practice questions by themselves. In the experimental group, the supplemental instruction leader walked around the room helping students. At the end of the problem-solving session, both instructors explained and gave the answers instead of facilitating discovery by the students or asking students to explain their solutions. Both instructors referred to their prepared notes during the lecture.

A comparison of three students with score range on their final exam of 70-75, 80-85 and 90-95 were examined for both the control and experimental groups. It was found that both instructors had similar grading policy. Working together the professors developed the following rubric to grade the example, $\lim_{x\to 2}\frac{x^2+4x-12}{x^2-2x}$:

- Two points be awarded if the correct solution and justification were given.
- One point be awarded if appropriate work was shown but one computational or conceptual error was made or if only the correct solution was given but no further work was shown.
- Zero point be awarded if an incorrect, irrelevant, or incoherent solution was given.

Based on the observations, it is safe to conclude that both instructors' presentation of course material, pedagogical strategy, and grading policy were similar. The only pedagogical difference between the two groups was the means by which homework was assigned. The control group was assigned homework from the textbook which was done by pen-and-paper, whereas, the experimental groups used the online homework management system, WebAssign to do their homework. The homework questions were fundamentally the same but the numbers within the problems were different.

Research Question 1

How do the metacognitive and study skills of students in a calculus class with supplemental instruction and online homework differ from those of students in a traditional class?

All students in the study were registered in a section of first-semester calculus and observed for one semester. No significant difference was expected in the metacognitive and resource management strategies between students in the supplemental instruction/online homework sections and those students in the traditional sections.

Eight subsections of metacognitive and resource management strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation and Help Seeking) were included in the modified MSLQ. Independent samples t-tests were done to confirm whether there was a significant difference in the mean students' response between the control and experimental groups at the 5% level of significance for each subsection. Table 5 showed the findings for each subsection.

Metacognitive Self-Regulation

Self-Regulation learning strategies measured how often students think about what they are reading, doing, or studying as they solve mathematics problems. The mean and standard deviation of the control and experimental groups, shown in Table 5, were very similar. Thus, there was not a noticeable difference in students' response in terms of their metacognitive self-regulation learning strategies. An independent samples t-test (results in Table 5) verified this observation. The results suggested that students in the supplemental instruction/online homework sections and students in the traditional sections did not differ significantly in their awareness, knowledge, and control of cognition (Pintrich et al., 1991). Similar results were found for Rehearsal, Organization, Critical Thinking, Time and Study Environment, Effort Regulation and Help Seeking.

Table 5. *Metacognitive and Resource Management Strategies: Mean student response data*.

Strategy	N	Mean	Std. Dev.	t	P
Self-Regulation				0.056	0.955
Traditional Class	56	3.62	0.51		
Supplemental Class	56	3.61	0.61		
Time and Study Environment				-1.819	0.072
Traditional Class	56	3.74	0.49		
Supplemental Class	56	3.91	0.49		
Effort Regulation				0.000	1.000
Traditional Class	56	3.16	0.51		
Supplemental Class	56	3.16	0.51		
Help Seeking				0.482	0.631
Traditional Class	56	3.57	0.75		
Supplemental Class	56	3.50	0.71		
Rehearsal				-0.287	0.775
Traditional Class	56	3.97	0.84		
Supplemental Class	56	4.01	0.81		
Elaboration				-2.032	0.045
Traditional Class	56	3.67	0.90		
Supplemental Class	56	3.99	0.77		
Organization				-0.113	0.910
Traditional Class	56	3.68	0.77		
Supplemental Class	56	3.70	0.89		
Critical Thinking				0.575	0.566
Traditional Class	56	3.34	1.03		
Supplemental Class	56	3.23	1.02		

The most significant finding falls under elaboration. Elaboration learning strategies included paraphrasing or summarizing course concepts and connecting new information to what the students already knew. The mean and standard deviation, shown in Table 5, did not provide a strong evidence that the two groups were different in terms of their elaboration learning strategies. An independent samples t-test was done to verify the no-substantial-difference finding. However, the results from the t-test (displayed in Table 5) showed a significant difference.

There was a significant difference in mean students' responses between the control and the experimental groups; $t(110) = -2.032$, $p = 0.045$. The supplemental group had $M = 3.99$, $SD = 0.77$, and the traditional group had $M = 3.67$, $SD = 0.90$. The Cohen's d for the learning strategy of elaboration was 0.4. That is, the difference in elaboration learning strategies between students in a class with supplemental instruction/online homework and students in a traditional class was 0.4, which indicates a small effect size. Thus, the difference between the two groups of students is not all that meaningful.

Summary

The findings for this research question showed no significant difference between the control group and the experimental group in seven out of eight sub-scales of metacognitive and resource management learning strategies: metacognitive self-regulation, time and study environment, effort regulation, help seeking, rehearsal, organization, and critical thinking. However, students with supplemental instruction/online homework showed a slightly higher level of elaboration learning strategies than students who were not exposed to supplemental instruction/online homework. In a similar study, Peacock (2008) found that students who had supplemental instruction had a higher level of organization skills. Additionally, no significant difference between the control and experimental groups was found in the other subscales.

Research Question 2

Is there a significant difference in the posttest between students in a class with supplemental instruction/online homework and students in a traditional class?

All students met the requirements to be enrolled in this calculus course. Some students took a pretest to eliminate the assumption that the pretest is not priming them to perform better on the posttest. However, it is expected that students who had supplemental instruction and online homework would outperform the students who did not.

The mean posttest scores of students in a supplemental instruction/online homework class was 79.19 (14.63) and of students in a traditional class was 63.00 (25.25), as shown in Table 6. The mean alone did not provide a strong evidence that the two groups were different in terms of their posttest scores.

Table 6. *Mean posttest scores of students*

Students	N	Mean	Standard Deviation
Traditional	55	63.00	25.25
Supplemental	54	79.19	14.63

Interaction Effects of Type of Class and Pretest on Posttest

A 2x2 between-subjects analysis of variance (ANOVA) examined the effect of the pretest on students in the treatment group and those in the control group by testing the following hypotheses:

H_0: Pretest and type of class interaction have no significant effect on students' posttest score.

H_1: Pretest and type of class interaction have a significant effect on students' posttest score.

The ANOVA results, which appeared in Table G-4 (Appendix G), failed to reveal an interaction between students taking the pretest and the type of class, $F(1, 105) = 0.098$, $p = 0.755$, $\alpha = 0.05$; hence, it cannot be concluded that the effect of taking the pretest versus not taking the pretest was different for students in the control and experimental groups.

Since there was no significant interaction of pretest and type of class on students' posttest score, main effects of pretest and main effects of type of class test on the control vs experimental groups were performed.

Main Effects of Pretest on Posttest

An ANOVA to determine if the mean score received on the posttest was different for students who took the pretest and students who did not take the pretest was done testing the following hypotheses:

H_0: Pretest has no significant effect on students' posttest score.

H_1: Pretest has a significant effect on students' posttest score.

The ANOVA (displayed in Appendix G) failed to reveal a main effect of pretest on students' posttest score, $F(1, 105) = 0.17$, $p = 0.896$, $\alpha = .05$; hence, it cannot be concluded that the mean score received on the posttest was different for students who took the pretest and students who did not take the pretest. This means that there was no pretest sensitization. Thus, the pretest did not diminish the treatment effectiveness.

Main Effects of Type of Class on Posttest

Finally, an ANOVA to determine if the mean score received on the posttest was different for the control group and the experimental group was conducted testing the following hypotheses:

H_0: Type of class has no significant effect on students' posttest score.

H_1: Type of class has a significant effect on students' posttest score.

The ANOVA (displayed in Appendix G) revealed a main effect of the type of class on students' posttest score, $F(1, 105) = 16.413$, $p = 0$, $\alpha = 0.05$; hence, it can be concluded that the mean score on the posttest is different for the control group and the experimental group. The Cohen's d for students' posttest scores was 0.8. That is, the difference in posttest scores between students in a class with supplemental instruction/online homework and students in a traditional class was 0.8, which indicates a large effect size. Thus, the treatment had a significant effect on students' posttest score.

The ANOVA tests revealed whether there was an impact of pretest and type of class interaction on posttest, pretest on posttest, and type of class on posttest, but it failed to consider any possible relationship between students' posttest score and other independent variables such as gender, race, class level, and number of registered courses, so a multiple regression model on the experimental group was analyzed as well.

Regression Analysis

First a simple linear regression model (called Model 1) was done to determine if students' pretest scores are predictors of their posttest scores. The regression equation found was:

$$Predicted\ Posttest = 76.93 - 0.01(PretestScore) + \epsilon$$

The t-statistic from the regression analysis, displayed in Appendix G, indicated that pretest scores are insignificant predictors of posttest scores. This result corroborated the pretest result from the ANOVA above.

A second regression model (Model 2) was calculated to predict students' posttest scores based on their gender, race, class level, and the number of courses they are taking. The regression equation found was:

$$Predicted\ Posttest = 68.99 - 8.81(Gender) - 1.75(Race) - 0.17(Class) + 3.64(RegisteredCourses) + \epsilon$$

The t-statistic from the regression analysis, displayed in Appendix G, revealed that none of the coefficients of the independent variables: gender, race, class level, or the number of registered courses had a significant effect on posttest score of students.

A third regression model (Model 3) was computed to determine if students' gender, race, class level, the number of courses they are taking, or their pretest scores are related to their posttest scores. The regression equation found was:

$$Predicted\ Posttest = 69.54 - 0.02(PretestScore) - 8.98(Gender) - 1.78(Race) - 0.13(Class) + 3.76(RegisteredCourses) + \epsilon$$

The t-statistic from the regression analysis, displayed in Appendix G, revealed that none of the coefficients of the independent variables: pretest scores, gender, race, class level, or the number of registered courses had a significant effect on students' posttest scores.

Summary

These results showed the interaction of pretest and type of class did not have a significant effect on students' posttest score. Additionally, there was no substantial effect of pretest on posttest, but the treatment influenced students' posttest score. It appeared that students in a class with supplemental instruction/online homework earned higher posttest scores than students in a traditional class. These results were consistent with previous studies which showed that students who attended supplemental instruction sessions performed better based on their final course grade and/or GPA (Blanc et al., 1983; Fayowski, 2006; Fayowski & MacMillan, 2008; Kenney, 1988; Ning & Downing, 2010; Peacock, 2008; Shaya et al., 1993; Vorozhbit, 2012) and online homework enhanced students' learning based on their exam scores (Burch & Kuo, 2010; Cheng et al., 2004; Zerr, 2007).

The t-statistic in the regression analysis revealed that pretest score, gender, race, class level, or the number of registered courses were insignificant predictors of posttest scores. As such, it cannot be concluded that there was a significant difference in the posttest scores among students based on their pretest scores, gender, race, class level, or the number of courses they registered for.

Research Question 3

What are instructor's and students' perception and experiences of supplemental instruction and online homework?

A survey was distributed to students in the calculus class with supplemental instruction/ online homework to get some information on their attitude towards and experience working with supplemental instruction and online homework/WebAssign. Students had to choose the best choice (Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Strongly agree) for each item on the survey. To substantiate the findings from the survey, fourteen students from the class were interviewed to determine what worked and/or what did not work for them.

Students

As displayed in Appendix H (Figures H-1 and H-2), approximately 80% of the students strongly agreed or somewhat agreed that the online homework using WebAssign helped them to understand the course material better and improved their problem-solving skills respectively. Student1 voiced the majority opinion:

> WebAssign is helpful. It helps me answer the question(s) and it helps me to understand the material better.

Almost all the students loved the benefits of having tutorial videos to watch when they needed help in solving a mathematics problem or understanding a concept. Student2 noted

> The best thing about WebAssign is the videos; visually seeing what I'm doing helps me to understand the material better.

Student3 had the same opinion

> My favorite feature is the videos, because I can actually see someone doing it hands on. I'm more of a visual learner, rather than a kinesthetic or listening learner.

One student noted that a good grade can be obtained on the online homework without understanding the concepts or how to solve the problems because of the multiple attempt feature. Student4 said

> Some topics I can guess the answer without knowing the concept. For example, some questions have like four choices and we've got five attempts to answer the question correctly, so I can use four trials and then the last one I will get it right.

On the other hand, ten students mentioned that the multiple attempt feature is one of the best aspects of online homework using WebAssign. Student5 voiced the majority opinion:

> I like best that WebAssign gives some, at least five, chances without being penalized to get the answer right.

As illustrated in Appendix H (Figures H-3, H-4, H-5, and H-6), students believed that online homework using WebAssign helped them to score higher on tests (76%), helped them to be better prepared for tests (85%), their time spent on WebAssign was worthwhile (71%), and homework using WebAssign was more beneficial than homework using paper and pen (62%). Student2 voiced the majority opinion:

> It was helpful to have videos to watch and to have other sample problems to do when I was confused about a certain problem. I like the additional resources and opportunities to get the problems right. This helps me to do better and boost my grade.

Ten of the fourteen students agreed that "WebAssign homework was more helpful than the textbook homework."

Student7 explained

> There are more helpful tools on WebAssign than there is with me doing the homework on my own where all I have is my notes and the textbook to rely on. On WebAssign I can switch to a different question, or I can watch a video on how it's done, or I can go to the exact spot in the textbook as to where I can find the problem. So, it is better.

As displayed in Appendix H (Figures H-7 and H-8) more than 70% of the students disagreed with the following statements: “The questions on WebAssign did not correspond with the material in the textbook” and “The questions on WebAssign did not match the material discussed in the lecture”. Student4 said

> The problems are very similar to the ones described in class with or without a few more steps but I like that. I get more opportunity to practice what we learned.

Appendix H (Figure H-9) showed that 43% of the students strongly disagreed or somewhat disagreed that “online homework using WebAssign was frustrating” while 35% strongly agreed or somewhat agreed with the statement. Appendix H (Figure H-10) showed 60% of the students agreed that online homework using WebAssign was time consuming. Student6 said, “I don’t like how tedious and clumsy it is to actually get the assignment done.” One of the shortcomings of WebAssign was that it accepts only a particular format of the answer, which can be daunting for some students. Student6 voiced the majority opinion:

> I can’t stress this enough: it’s extremely frustrating to try to input the answers using a keyboard.

Student3 elaborated

> The fact that I don't know exactly how WebAssign wants me to enter the answer is frustrating and annoying.

As displayed in Appendix H (Figures H-11 and H-12), the overwhelming sentiments of the students were “they liked that WebAssign immediately grades their homework” (92%) and “they liked that WebAssign showed them the step-by-step solution of a similar problem when they asked for help" (94%). The students' interviews corroborated those findings. Student6 voiced the majority opinion:

> WebAssign shows you an example of how a problem is done and then you learn from that and fix your mistakes; the instant feedback is great.

Another student, Student7 said

> I like best that WebAssign tells you right away if the question you did is correct or incorrect and it also has practice examples so if you're unable to do the homework question, you can try the practice example and then attempt the actual homework question.

As illustrated in Appendix H (Figures H-13, H-14, H-15, and H-16), more than 75% of the students found it easy to use the WebAssign homework system, thought the feedback section of the system was very beneficial, felt good about their progress in the course as a result of using WebAssign, and preferred to do their homework using WebAssign so they can use technology. Seven students commented that online homework was convenient. Student7 noted

> It [online homework on WebAssign] was very convenient. I could do my homework anywhere on my phone even when I am on the bus.

One student disliked online homework because it is computerized. Student3 said "I don't like anything on the computer, too much navigating and I don't like it."

Appendix H (Figures H-17, H-18, H-19, and H-20) showed that more than 75% of the students strongly agreed or somewhat agreed that supplemental instruction enabled them to understand the course better, become better mathematics problem solvers, and perform better on tests, boosting their grades. Problem solving strategies and the use of index cards were emphasized in supplemental instruction sessions. Student3 voiced the majority opinion:

> I feel like it [supplemental instruction session] was very helpful, and it helped me learn the material better and reinforced what I learned the day before.

Student1 noted,

> The best part is it reviewed what we learned in the past and prepared us to do well in tests.

The supplemental instruction leader prepared students for upcoming tests/examinations by solving the review sheets prepared by the class instructor.

As displayed in Appendix H (Figures H-21 and H-22), students believed that supplemental instruction sessions were helpful (84%) and validated that the supplemental instruction leader was available to assist them from the first week of classes (81%). All the students interviewed agreed that supplemental instruction sessions were helpful. Student1 voiced the majority opinion,

> I think SI session is a very helpful way to understand the topics; it helps us to solve and understanding the questions, and the supplemental instruction leader is very helpful.

Student7 believed

> Supplemental instruction provides us with an extra resource from day 1, so in case we need to approach someone besides the professor.

Appendix H (Figure H-23) showed that approximately 69% of the students met with the supplemental instruction leader outside the mandatory supplemental instruction sessions to get additional assistance with mathematics. Eleven students agreed that the supplemental instruction leader was always available to assist them outside of class time. Student5 noted

> My supplemental instruction leader is always ready to hear if we have any problems, is very patient, and always makes sure we understand a topic before we leave her table.

As displayed in Appendix H (Figures H-24 and H-25), 69% of students believed the time spent in supplemental instruction sessions were worthwhile while 77% agreed that they learned appropriate study strategies in supplemental instruction sessions. Activities in supplemental instruction sessions focused on notetaking, text reading, problem solving and study habits. Student3 noted,

> I found better ways of memorizing formulas and knowing when and where to use the correct formula in SI sessions.

Student4 has the same opinion:

> I found recopying my notes after class helped me in understanding the course. This is something I learnt from the SI leader.

As illustrated in Appendix H (Figure H-26), approximately 75% of students believed supplemental instruction sessions motivated them to study. Five students believed attending the supplemental instruction sessions motivated them to get their schoolwork done. Student2 noted,

> Sometimes I felt like I was slacking then I would go to SI sessions and realized I have to review my class notes and complete the homework in order to have questions for the next session.

Appendix H (Figure H-27) showed approximately 64% of the students disagreed with the following statement: “The supplemental instruction leader does all the work for me.” 11 out of 14 students claimed the leader does not do any work for them. Student4 noted,

> The SI leader asked us questions to get our train of thought and procedure of how to solve a problem instead of solving the problem for us.

As displayed in Appendix H (Figure H-28), approximately 74% of the students disagreed with the statement “I was more confused about the course material after attending supplemental instruction sessions." One student agreed with the statement. Student3 said,

> I like when we do review in SI sessions because I found it helpful. Otherwise, I found it [supplemental instruction session] to be confusing.

Instructor

InstructorExp likes teaching courses with supplemental instruction. She has been teaching mathematics courses which have supplemental instruction attached to them since 2010. She noted

> Students have the opportunity to discuss homework questions, clarify any confusions they have, or study for a test in a safe learning environment in supplemental instruction sessions.

Students have additional time to do calculus with the supplemental instruction leader, who is less intimidating for some students. She observed,

> Many SEEK students needed the extra help to boost their study skills and effort to practice and succeed in calculus.

The instructor felt that the best feature of supplemental instruction is the supplemental instruction leader. She said

> The SI leader would walk around the room helping students during the lecture. For example, he (the SI leader) may have observed students were not using 'product rule' to differentiate a 'product' and offered guidance. That extra person in the room assisting students was great.

The supplemental instruction leader also posted solutions to the review sheets and important dates on Blackboard, which every student has accessed to. He was available outside of class to help students who needed an additional boost with calculus or tips on study strategies.

Sometimes, students do not make connections when a concept is discussed in terminology that differed from that used by their class instructor. InstructorExp, noted

> In supplemental instruction sessions, the SI leader may not have explained the procedures the same way I did during the class lecture so students are more confused after the session. This is one of the challenges of supplemental instruction.

In general, instructors do not always maintain the same pace nor explain procedures in the same way.

Online homework using WebAssign is another tool students have to their advantage when doing calculus. The instructor observed

> From my experience, students have performed better since we started using WebAssign for homework assignments.

The instructor found the immediate feedback helped the students because they are aware of their progress. Also, homework being online forced students to do the homework because of the due date.

> Students learn calculus by practicing not just by looking at me doing it on the board and this is evident in their test scores (InstructorExp).

WebAssign has several features which allowed students to practice other sample problems. It also simplifies the creation and grading of homework assignments. The instructor noted,

> I like that once I create a course the next semester I just recreate that course by using the course copy function.

One disadvantage of using WebAssign for homework is the impossibility of determining who actually did the work. Students can get help from friends, families, or tutors.

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to evaluate the effectiveness of supplemental instruction and online homework in improving students' performance and understanding in a first-semester calculus course at a large urban four-year college located in the borough of Queens. This was achieved by answering three research questions.

1. How do the metacognitive and study skills of students in a calculus class with supplemental instruction and online homework differ from those of students in a traditional class?
2. Is there a significant difference in the posttest scores between students in a class with supplemental instruction/online homework and students in a traditional class?
3. What are instructor's and students' perception and experiences of supplemental instruction and online homework?

Research Question 1

The purpose of Research Question 1 was to determine if there was a significant difference in metacognitive and resource management strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation and Help Seeking) between students in a class with supplemental instruction/online homework and students in a traditional class. Based on the results from the modified MSLQ there were no significant differences between students in a class with supplemental instruction/online homework and students in a traditional class in seven out of eight sub-scales of metacognitive and resource management learning strategies: metacognitive self-regulation, time and study environment, effort regulation, help seeking, rehearsal, organization, and critical thinking. However, students with supplemental instruction/online homework showed a higher level of elaboration learning strategies than students who were not exposed to supplemental instruction/online homework. This could be because students with supplemental instruction/online homework have more opportunities to relate new concepts with prior concepts/knowledge and exposure to more examples and practice. In a similar study, Peacock found that students who had supplemental instruction had a higher level of organization skills. Also, there was no significant difference between the control and experimental groups in the other subscales.

Research Question 2

The purpose of Research Question 2 was to determine whether there is a significant difference in the posttest scores between students in a class with supplemental instruction/online homework and students in a traditional class. In both the control and experimental groups, there were students who took a pretest and students who did not.

The interaction of pretest and type of class (control or experimental) nor pretest alone did not have a significant effect on students' posttest score. However, there was sufficient evidence to conclude that the mean score on the posttest was different for students in a class with supplemental instruction/online homework and students in a traditional class. A multiple linear regression model revealed that none of the coefficients, pretest scores, gender, race, class level, and the number of registered courses, has a significant effect on students' posttest score. These results are consistent with previous studies which showed that students who attended supplemental instruction sessions performed better based on their final course grade and/ GPA (Blanc et al., 1983; Fayowski, 2006; Fayowski & MacMillan, 2008; Kenney, 1988; Ning & Downing, 2010; Peacock, 2008; Shaya et al., 1993; Vorozhbit, 2012) and online homework enhances students' learning based on their exam scores (Burch & Kuo, 2010; Cheng et al., 2004; Zerr, 2007).

Students in a class with supplemental instruction/online homework have more access to the course material and problem-solving practice during supplemental instruction sessions and on WebAssign. These supplemental resources (supplemental instruction sessions and WebAssign) facilitated "double exposure" to the course content. The findings from research question 1 corroborated the notion of "double exposure" because students in supplemental instruction/online homework classes demonstrated a higher level of elaboration learning strategies than students in the traditional classes. This "double exposure" to the course content could have influenced students in the experimental group posttest scores.

Research Question 3

The purpose of Research Question 3 was to get some information on student and instructor attitude towards and experience working with supplemental instruction and online homework using WebAssign. Based on the survey results, more than 75% of the students agreed that attending supplemental instruction sessions and/or doing online homework using WebAssign have helped them to understand the course better, improved their problem-solving skills, and be better prepared for tests which boosted their performance in the class. Student1 voiced the majority opinion: “WebAssign is helpful. It helps me answer the question(s) and it helps me to understand the material better.” When asked about supplemental instruction sessions, she noted “The best part is it [supplemental instruction session] reviews what we learned in the past and prepared us to do well in tests.”

Results from the survey showed that the overwhelming sentiments of the students were that they liked that “WebAssign immediately grades their homework” (92%) and “WebAssign shows them the step-by-step solution of a similar problem when they asked for help” (94%). The students’ interviews corroborated these findings. Sixty percent of the students surveyed agreed that online homework using WebAssign is time consuming. Student6 voiced the majority opinion: “It’s extremely frustrating to try to input the answers using a keyboard.”

Seventy seven percent of the students surveyed agreed that they learned appropriate study strategies in supplemental instruction sessions. Student3 noted “I found better ways of memorizing formulas and knowing when and where to use the correct formula”. Supplemental instruction sessions emphasized appropriate study skills and strategies for succeeding in the course.

The instructor who taught the experimental group likes teaching courses with supplemental instruction. She noted “students have the opportunity to discuss homework questions, clarify any confusions they have, or study for a test in a safe learning environment in supplemental instruction sessions.” The instructor noted the best feature of supplemental instruction is the supplemental instruction leader who assisted the students with calculus or study strategies inside and outside of the classroom. In general, instructors do not always maintain the same pace nor explained procedures in the same way. The instructor said “In supplemental instruction session, the SI leader may not have explained the procedures the same way I did during the class lecture so students are more confused after the session.”

Online homework using WebAssign is another tool students have to their advantage when doing calculus. The instructor observed “From my experience, students have performed better since we started using WebAssign for homework assignments.” One disadvantage of using WebAssign for homework is it is impossible to say who actually did the work. Students can get help from friends, families, or tutors.

Limitations

The conclusions made in this study are difficult to generalize. This study was conducted for one semester in one course at a single college. The small sample size and the intact sections/classes limits claims of generalizability to large population.

The sample was not randomly selected. Students from four intact sections of first-semester calculus were utilized. The validation of true group equivalence in the control and experimental groups was not possible due to the lack of students' prior academic records. Also, not all students in the study took the pretest.

They were two instructors in the study. In order to minimize instructor difference, several classroom observations and a comparison of several of the students graded final exam from each instructor were done to establish consistency in pedagogy and grading. Instructor quality (knowledge, degrees, etc.) was not measured and may have influenced the academic achievement between the groups.

This study did not account for "double exposure" of the course content. It is fair to say that the students exposed to supplemental instruction/online was receiving more guidance and practice in the course concepts. Thus, "double exposure" to the course content could have influenced students' posttest scores.

Every student in the study answered the questionnaire and survey. However, it is difficult to say if they read and thought the question through before answering. And, if they answered truthfully or they chose the answer that is sociably acceptable.

An unanticipated limitation was the difficulty to get instructors to participate in this study. All instructors on the class schedule who were teaching a traditional calculus class were emailed a request to volunteer but the response was minimal.

Recommendations

A primary recommendation is to do a follow-up study to determine if there is a significant difference in metacognitive and resource management strategies between students in a class with supplemental instruction/online homework and students in a traditional class for another semester. The study will focus on the metacognitive and resource management strategies of Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation and Help Seeking.

Another recommendation is to track the students in the experimental group for an additional semester. The study will focus on the pattern of enrollment in other mathematics courses and the achievement levels of the students. However, in the follow up study there is no supplemental instruction/online homework.

This study did not answer a basic question: Did the difference between the groups come from the effects of the Supplemental Instruction sessions and/or Online Homework using WebAssign, or did the difference come through a form of "double exposure" to the course content? It is reasonable to argue that one group was receiving more exposure to course content than the other group.

There are only a few colleges that have used or are using supplemental instruction and online homework. So, there is a lack of research on the application of supplemental instruction and online homework in first-semester calculus. Also, continued research using supplemental instruction and/ or WebAssign in other mathematics courses should be undertaken.

Instructors and supplemental instruction leaders should reiterate during lectures and supplemental instruction sessions that the solution to a mathematics problem can be written in different ways. For example, $5\sqrt{2} + 11$ is the same as $11 + 5\sqrt{2}$. At times, students would input one format of the correct answer in WebAssign and WebAssign would say it's incorrect, so students should be aware that they can reorder the solution and input it again.

For future doctoral students, carefully think through your research focus, data collection methodologies and analysis as you start your doctoral program. One way to accomplish this goal is by reading past studies, dissertations, and literature on your research interest. There are lots of scholarly articles at your disposal via TC library.

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Appendix A

Pretest

PRETEST

Attempt all questions!

Solve the equation.

1) $-(5y + 9) - (-4y - 8) = 6$ 1) ______

A) $y = -5$ B) $y = 11$ C) $y = 7$ D) $y = -7$

Solve the equation. Express radicals in simplest form.

2) $x^2 - x = 56$ 2) ______

A) $\{-7, -8\}$ B) $\{1, 56\}$ C) $\{7, 8\}$ D) $\{-7, 8\}$

3) $2x^2 = 30$ 3) ______

A) $\{16\}$ B) $\{15\}$ C) $\{-\sqrt{15}, \sqrt{15}\}$ D) $\{-15, 15\}$

Simplify the complex fraction.

4) $\dfrac{4 + \dfrac{2}{x}}{\dfrac{x}{3} + \dfrac{1}{6}}$ 4) ______

A) $\dfrac{x}{12}$ B) $\dfrac{12}{x}$ C) 1 D) 12

Write an equation of the line through the given point with the given slope. Write the equation in slope–intercept form.

5) $(4, -2)$, $m = \frac{1}{2}$ 5) ______

A) $y = \frac{1}{2}x + 4$ B) $y = 2x - 4$ C) $y = \frac{1}{2}x - 4$ D) $y = -\frac{1}{2}x - 4$

Find the square root.

6) $-\sqrt{441}$ 6) ______

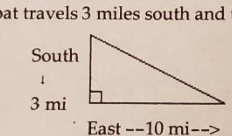
A) -220 B) Not a real number
C) 21 D) -21

7) $\sqrt{-441}$ 7) ______

A) 21 B) -21
C) Not a real number D) 220

Solve the problem. Give the answer to the nearest thousandth if necessary.

8) A boat travels 3 miles south and then 10 miles east. How far is the boat from its starting point? 8) ______



A) 6.5 mi B) 5.22 mi C) 10.44 mi D) 54.5 mi

Complete the ordered pairs. Then graph the equation by plotting the points and drawing a line through them.

9) $x + y = -2$ (0,), (-2,), (3,)

1

Appendix B

Modified MSLQ

STUDY HABITS AND LEARNING SKILLS

This questionnaire asks you about your study habits and learning skills in this course.

There are no correct or incorrect answers.

PLEASE RESPOND TO THE QUESTIONNAIRE AS ACCURATELY AS POSSIBLE, REFLECTING YOUR OWN ATTITUDES AND BEHAVIORS IN THIS COURSE.

1) What is your gender?

- ❍ Male
- ❍ Female
- ❍ Prefer not to say

2) What is your age?

- ❍ 18-25
- ❍ 26-34
- ❍ 35-50
- ❍ 50 or over

3) What is your race?

- ❍ White/Caucasian
- ❍ African American
- ❍ Hispanic
- ❍ Asian
- ❍ Native American
- ❍ Pacific Islander
- ❍ Other

4) What is your class level?

- ❍ Freshman
- ❍ Sophomore
- ❍ Junior
- ❍ Senior

5) Choose the reason(s) for taking this course.

- ❑ It is a required course for my major.
- ❑ It is an elective course which fits my schedule.
- ❑ It will improve my career prospects.
- ❑ It was recommended by someone.
- ❑ Content seems interesting.

6) How many courses are you taking this semester (including this course)?

- ❍ One
- ❍ Two
- ❍ Three
- ❍ Four
- ❍ Five or more

7) During class time I often miss important points because I'm thinking of other things.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

8) When I become confused about something I'm reading or doing for this class, I go back and try to figure it out.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

9) Before I study new course material thoroughly, I often skim it to see how it is organized.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

10) I try to change the way I study in order to fit the course requirements and instructor's teaching style.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

11) When studying for this class I try to determine which concepts I don't understand well.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

12) If I get confused taking notes in class, I make sure I sort it out afterwards.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

13) I usually study in a place where I can concentrate on my course work.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

14) I make good use of my study time for this course.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

15) I find it hard to stick to a study schedule.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

16) I have a regular place set aside for studying.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

17) I make sure I keep up with the weekly assignments for this course.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

18) I attend class regularly.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

19) I often find that I don’t spend very much time on this course because of other activities.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

20) I often feel so lazy or bored when I am studying for this class that I quit before I finish what I planned to do.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

21) I work hard to do well in this class even if I don't like what we are doing.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

22) When the course work is difficult, I give up or only study the easy parts.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

23) Even when course materials are dull and uninteresting, I manage to keep working until I finish.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

24) Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

25) I ask the instructor to clarify concepts I don’t understand well.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

26) When I can’t understand the material in this course, I ask another student in this class for help.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

27) I try to identify students in this class whom I can ask for help if necessary.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

28) When I study for this class, I practice saying the material (for example: definitions and formulas) to myself over and over.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

29) When studying for this class, I read my class notes and solve math problems over and over.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

30) I memorize key words to remind me of important concepts in this class.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

31) I make lists of important terms, definitions, and formulas for this course and memorize the lists.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

32) When I study for this class, I pull together information from different sources, such as lectures, textbook, homework, and discussions.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

33) I try to relate ideas in this course to those in other courses whenever possible.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

34) When studying for this class, I try to relate the material to what I already know.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

35) When I study for this course, I outline the material to help me organize my thoughts.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

36) When I study for this course, I go through my class notes and try to find the most important ideas.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

37) I make simple charts, diagrams, or tables to help me organize the course material.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

38) I often find myself questioning things I hear or read in this course to decide if I find them convincing.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

39) I try to play around with ideas of my own related to what I am learning in this course.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

40) Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

41) I treat the course material as a starting point and try to develop my own ideas about it.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

Thanks for taking the time to complete this questionnaire. I greatly appreciate your cooperation and help with this research.

Appendix C

Posttest

Queens College
Department of Mathematics

Mathematics 141 **Final Examination** **Fall 2015**

Instructions: Answer *all* questions. *Show all work.* Justify your answers. If you use a calculator, show the commands that you used.

1. a) (4 points) Find the domain and the range of the function $p(x) = \sqrt{9 - x^2}$. Express your answer using interval notation.
   b) (4 points) Let $F(x) = (\sin(x^3) + 9)^2$. Find functions f, g, and h such that F is the composition of f, g, and h (i.e., $F = f \circ g \circ h$).

2. Compute, *without using a calculator*, the following limits. (Real numbers, ∞, and $-\infty$ are acceptable answers.)
   a) (4 points) $\lim_{x \to 2} \frac{\sqrt{x^2+12}-4}{x-2}$
   b) (4 points) $\lim_{x \to -2} \frac{|x|-2}{x^2+4}$
   c) (4 points) $\lim_{x \to (\frac{\pi}{2})^+} \tan x$
   d) (4 points) $\lim_{x \to -\infty} \frac{x^2-3}{\sqrt{4x^4+1}}$

3. (8 points) Use the table feature of your calculator to estimate $\lim_{x \to \infty}((x^3 - 5x^2)^{1/3} - x + 1)$ to two decimal places. Copy four rows of the table into your exam booklet.

4. (10 points) *Using the definition of the derivative*, find $f'(2)$ if

$$f(x) = \frac{1}{x^2 + 1}.$$

5. (8 points) Compute the linearization of the function $f(x) = x^{3/4}$ at $a = 16$ and use it to approximate $(16.08)^{3/4}$.

6. Compute $\frac{dy}{dx}$ (you need not simplify) if:
   a) (4 points) $x^3y + y^3x = 1$
   b) (4 points) $y = \frac{1}{\sqrt{x^2-1}}$
   c) (4 points) $y = \frac{\cos x+1}{\sin^2 x}$
   d) (4 points) $y = \left(\frac{x^2-2}{x^2+2}\right)^9$

7. a) (4 points) State the Intermediate Value Theorem.
   b) (4 points) Use this theorem to prove that the equation $x^2 - \sin x - 1 = 0$ has at least one solution in the interval $(0, 2)$.

8. (10 points) Find the intervals of increase and decrease, and the intervals of concavity for the function

$$y = \frac{x^2 + 1}{x^2 - 4}.$$

Sketch the graph of the function, making sure to label all relative maxima and minima, inflection points, and asymptotes. You are encouraged to use your graphing calculator to help with your sketches, but the important features of the graph must be justified by calculus.

9. (8 points) If 432 in^2 of material is available to make a box with a square base and an open top, find the largest possible volume of the box. Make sure to show that you found the largest volume possible.

10. (8 points) A particle is moving along a hyperbola $xy = 36$. As it reaches the point $(4, 9)$, the x-coordinate is decreasing at a rate of 12 cm/s. How fast is the y-coordinate of the point changing at that instant? Is the particle moving up or down? Justify your answer.

Appendix D

Survey

Online Homework

This questionnaire asks you about your experiences with online homework and WebAssign.

There are no correct or incorrect answers.

PLEASE RESPOND TO THE QUESTIONNAIRE AS ACCURATELY AS POSSIBLE, REFLECTING YOUR OWN EXPERIENCES WORKING WITH WEBASSIGN.

1) WebAssign homework helped me to better understand the course material.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

2) WebAssign homework is frustrating.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

3) WebAssign homework improved my problem solving skills.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

4) The time I invested on WebAssign was worthwhile.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

5) The questions on WebAssign do not correspond with the material in the textbook.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

6) WebAssign homework helped me to score higher on tests.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

7) WebAssign helps me to be better prepared for tests.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

8) WebAssign homework is more beneficial than the written homework.
- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

9) The questions on WebAssign do not match the material discussed in the lecture.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

10) I like that WebAssign immediately grades my homework.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

11) WebAssign helps me feel good about my progress in the course.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

12) The feedback section of WebAssign is very beneficial.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

13) I like that WebAssign show me the step-by-step solution of a similar problem when I ask for help.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

14) WebAssign homework is time consuming.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

15) I find it easy to use the WebAssign homework system.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

16) I prefer WebAssign homework so I can use technology (computer, phone, tablets).

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

Thanks for taking the time to complete this questionnaire. I greatly appreciate your cooperation and help with this research.

Supplemental Instruction Sessions

This questionnaire asks you about your experiences with supplemental instruction sessions.

There are no correct or incorrect answers.

PLEASE RESPOND TO THE QUESTIONNAIRE AS ACCURATELY AS POSSIBLE, REFLECTING YOUR OWN EXPERIENCES WITH ATTENDING SUPPLEMENTAL INSTRUCTION SESSIONS.

1) The supplemental instructor was available to assist me from the first week of classes.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

2) The supplemental instructor sessions are open to all students in the course and are attended on a voluntary basis.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

3) I discovered appropriate study strategies, e.g., note taking, questioning techniques, problem solving, and test preparation as the supplemental instructor reviews content material.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

4) I meet the supplemental instructor during the semester for follow-up and math problem solving sessions.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

5) This additional resource (supplemental instruction) provided me with more motivation to learn.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

6) The supplemental instructor sessions were helpful.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

7) The supplemental instructor sessions helped me to earn a better grade in the class.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

8) The supplemental instructor sessions helped me to improve my math skills.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

9) The supplemental instructor sessions helped me to understand the course better.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

10) The supplemental instructor does all the work for me.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

11) I was more confused about the course material after attending the supplemental instructor session.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

12) The time I spent attending the supplemental instructor sessions was worthwhile.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

13) The supplemental instructor sessions helped me prepare for tests.

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

Thanks for taking the time to complete this questionnaire. I greatly appreciate your cooperation and help with this research.

Appendix E

Student Interview

Interview Protocol: Students

1) Describe your experiences this semester with supplemental instruction?

2) Explain what you like best about supplemental instruction.

3) Explain what you like least about supplemental instruction.

4) Did supplemental instruction assist you in understanding the course material better? Explain.

5) Did supplemental instruction motivated you to complete course assignment? Explain.

6) Would you register for another math course if you knew it has supplemental instruction? Explain.

7) Describe your experiences this semester using WebAssign?

8) Explain what you like best about WebAssign.

9) Explain what you like least about WebAssign.

10) Do you use the help options (Read it, Watch it, Practice another version, Ask your teacher) on WebAssign? How often? When do you use them?

11) WebAssign homework was more helpful than the textbook homework. Do you agree with this statement? Explain.

12) Did WebAssign assist you in understanding the course material better? Explain.

13) Did WebAssign motivated you to complete homework on time? Explain.

14) Has this class changed your attitude toward mathematics in any way? If so, how?

15) Is there any other information that you would like to share with me?

Appendix F

Instructor Interview

Interview Protocol: Instructor

1) How long have you been teaching math at this institution?

2) Describe your teaching style.

3) What is supplemental instruction at this college? (Describe supplemental instruction)

4) Describe your experiences this semester with supplemental instruction.

5) What are the functions of the supplemental instructor inside of the classroom.

6) What are the functions of the supplemental instructor outside of the classroom.

7) What are the best features of Supplemental Instruction?

8) What are the worst features of Supplemental Instruction?

9) Describe your experiences with WebAssign this semester.

10) Why do you choose to use WebAssign for this course?

11) What features do you like best about WebAssign?

12) What features do you like least about WebAssign?

13) If you had a choice, would you assign homework using WebAssign in another math course? Explain.

14) Are there any other information that you would like to share with me?

Appendix G

Tables

Table G-1. *Reliability Statistics for Survey*

	Cronbach's Alpha	Cronbach's Alpha on Standardized Items	Number of Items
Online Homework	0.984	0.985	16
Supplemental Instruction	0.981	0.984	13

Table G-2. *Demographics of students*

Category	Control Group	Experimental Group	t	p
Gender			-1.722	0.088
Male	51.8% (n=29)	35.7% (n=20)		
Female	48.2% (n=27)	64.3% (n=36)		
Race			2.144	0.034
White/Caucasian	19.6% (n=11)	5.4% (n=3)		
African American	16.1% (n=9)	10.7% (n=6)		
Hispanic	26.8% (n=15)	30.4% (n=17)		
Asian	23.2% (n=13)	41.1% (n=23)		
Other	14.3% (n=8)	12.5% (n=7)		
Class Level			0.813	0.418
Freshman	60.7% (n=34)	69.6% (n=39)		
Sophomore	26.8% (n=15)	19.6% (n=11)		
Junior	12.5% (n=7)	10.7% (n=6)		
Reason for taking this course			-0.939	0.350
Required	91.1% (n=51)	91.1% (n=51)		
Elective	8.9% (n=5)	8.9% (n=5)		
Number of registered courses			-1.364	0.175
One	1.8 % (n=1)	0.0% (n=0)		
Two	0.0% (n=0)	0.0% (n=0)		
Three	10.7% (n=6)	5.4% (n=3)		
Four	50.0% (n=28)	50.0% (n=28)		
Five or more	37.5% (n=21)	44.6% (n=25)		

Table G-3. *Metacognitive and Resource Management Strategies: Student response (raw data).*

Strategy	Question	Traditional Class					Supplemental Class				
		SD	D	N	A	SA	SD	D	N	A	SA
Self-Regulation	7	14	15	9	14	4	16	16	8	16	0
	8	1	3	4	19	29	0	7	2	21	26
	9	7	9	12	19	9	5	8	13	17	13
	10	6	12	10	17	11	2	12	13	22	7
	11	0	1	8	18	29	0	3	6	15	32
	12	1	7	6	23	19	4	7	5	15	25
Time and Study Environment	13	2	4	5	19	26	0	6	2	17	31
	14	3	6	12	17	18	0	10	4	23	19
	15	8	15	7	12	14	4	10	10	11	21
	16	5	8	9	24	10	3	9	6	27	11
	17	1	4	4	16	31	1	8	3	13	31
	18	0	3	2	15	36	0	5	1	7	43
	19	8	19	6	16	7	8	7	14	21	6
Effort Regulation	20	24	6	12	10	4	14	18	16	4	4
	21	2	2	10	15	27	1	5	5	17	28
	22	30	11	10	3	2	18	21	11	5	1
	23	0	3	7	17	29	3	5	5	22	21
Help Seeking	24	3	4	11	21	17	7	14	8	17	10
	25	0	5	11	18	22	4	4	5	20	23
	26	9	9	12	15	11	12	4	8	19	13
	27	10	4	13	18	11	5	3	13	24	11
Rehearsal	28	7	6	7	18	18	2	5	10	16	23
	29	1	1	7	19	28	3	3	5	24	21
	30	1	3	5	19	28	1	2	5	22	26
	31	6	5	8	16	21	2	9	4	22	19
Elaboration	32	6	6	7	18	19	0	4	8	21	23
	33	7	3	18	16	12	7	2	16	18	13
	34	2	5	11	16	22	0	3	3	22	28
Organization	35	4	6	8	25	13	3	2	20	15	16
	36	1	1	4	25	25	2	2	8	23	21
	37	10	10	12	13	11	3	10	19	13	11
Critical Thinking	38	7	5	19	12	13	6	11	14	18	7
	39	8	6	11	18	13	8	6	15	17	10
	40	5	6	18	14	13	6	9	9	21	11
	41	7	8	16	16	9	11	5	14	19	7

Key: SD – Strongly disagree D – Somewhat disagree N – Neither agree nor disagree
A – Somewhat agree SA – Strongly agree

Table G-4. *A 2x2 Between-Subjects Analysis of Variance of Pretest and Type of Class students are enrolled in on Posttest scores.*

Source	*df*	*SS*	*MS*	*F*	*p*
Corrected Model	3	7187.776[a]	2395.925	5.504	.001
Intercept	1	549889.647	549889.647	1263.196	.000
Tookpretest	1	7.475	7.475	.017	.896
Class	1	7144.810	7144.810	16.413	.000
Tookpretest * Class	1	42.758	42.758	.098	.755
Error	105	45708.187	435.316		
Total	109	602649.000			
Corrected Total	108	52895.963			

a. R Squared = .136 (Adjusted R Squared = .111)

Table G-5. *Summary for the Regression Model*

Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	0.029	0.001	-0.018	20.821
2	0.222	0.049	-0.025	20.897
3	0.228	0.052	-0.043	21.078

Table G-6. *An Analysis of Variance for the Regression Model*

Model		*df*	*SS*	*MS*	*F*	*p*
1	Regression	1	19.283	19.283	0.044	0.834
	Residual	54	23409.574	433.511		
	Total	55	23428.857			
2	Regression	4	1158.812	289.703	0.663	0.620
	Residual	51	22270.045	436.668		
	Total	55	23428.857			
3	Regression	5	1215.260	243.052	0.547	0.740
	Residual	50	22213.597	444.272		
	Total	55	23428.857			

Table G-7. *Coefficients of the variables used in the Regression Model*

		Unstandardized Coefficients		Standardized Coefficients		
Model		*B*	*Std. Error*	*Beta*	*t*	*p*
1	Constant	76.934	3.903		19.714	0.000
	Pretest	-0.014	0.066	-0.029	-0.211	0.834
2	Constant	68.991	21.740		3.173	0.003
	Gender	-8.808	5.993	-0.206	-1.470	0.148
	Race	-1.745	2.774	-0.087	-0.629	0.532
	Class	-0.167	4.175	-0.006	-0.040	0.968
	Registered	3.637	4.854	0.105	0.749	0.457
3	Constant	69.542	21.983		3.163	0.003
	Pretest	-0.024	0.067	-0.049	-0.356	0.723
	Gender	-8.975	6.063	-0.210	-1.480	0.145
	Race	-1.781	2.800	-0.088	-0.636	0.528
	Class	-0.126	4.213	-0.004	-0.030	0.976
	Registered	3.761	4.908	0.108	0.766	0.447

Table G-8. *Survey results on Online Homework*

Question Number	Strongly disagree (%)	Somewhat disagree (%)	Neither agree nor disagree (%)	Somewhat agree (%)	Strongly agree (%)
1	4	4	11	18	64
2	27	16	22	24	11
3	2	11	7	24	56
4	0	15	15	16	55
5	47	27	16	5	4
6	5	5	13	18	58
7	5	2	7	25	60
8	11	9	18	24	38
9	67	9	15	5	4
10	0	0	7	7	85
11	0	2	20	20	58
12	0	2	22	27	49
13	2	0	4	7	87
14	9	5	25	42	18
15	4	7	13	27	49
16	5	5	13	27	49

Table G-9. *Survey results on Supplemental Instruction*

Question Number	Strongly disagree (%)	Somewhat disagree (%)	Neither agree nor disagree (%)	Somewhat agree (%)	Strongly agree (%)
1	5	0	14	27	54
2	0	2	5	29	64
3	5	4	14	38	39
4	4	9	18	39	30
5	9	0	16	32	43
6	2	2	13	25	59
7	4	2	18	34	43
8	2	4	20	27	48
9	2	4	13	38	45
10	55	9	14	16	5
11	61	13	20	4	4
12	0	4	27	23	46
13	2	5	11	32	50

Appendix H

Figures

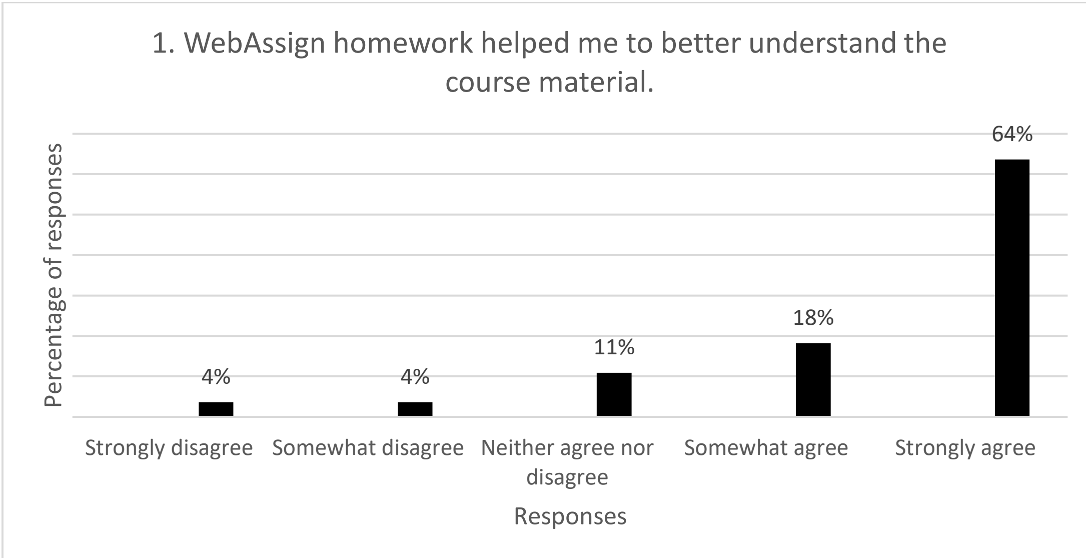


Figure H-1. Percentage of student responses to survey question

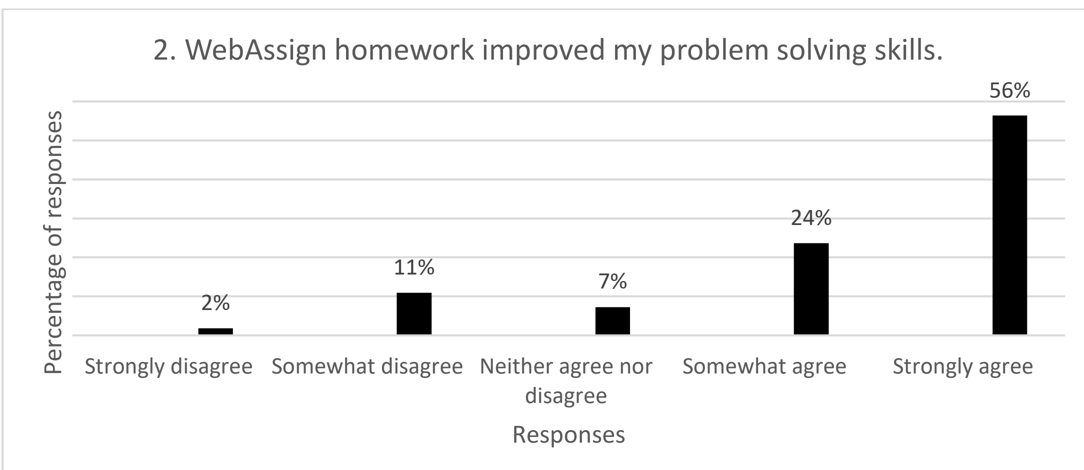


Figure H-2. Percentage of student responses to survey question

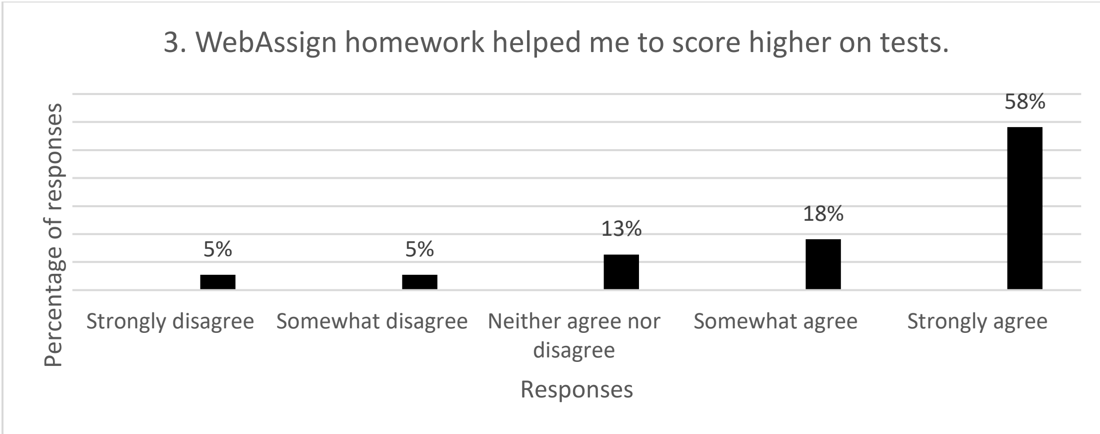


Figure H-3. Percentage of student responses to survey question

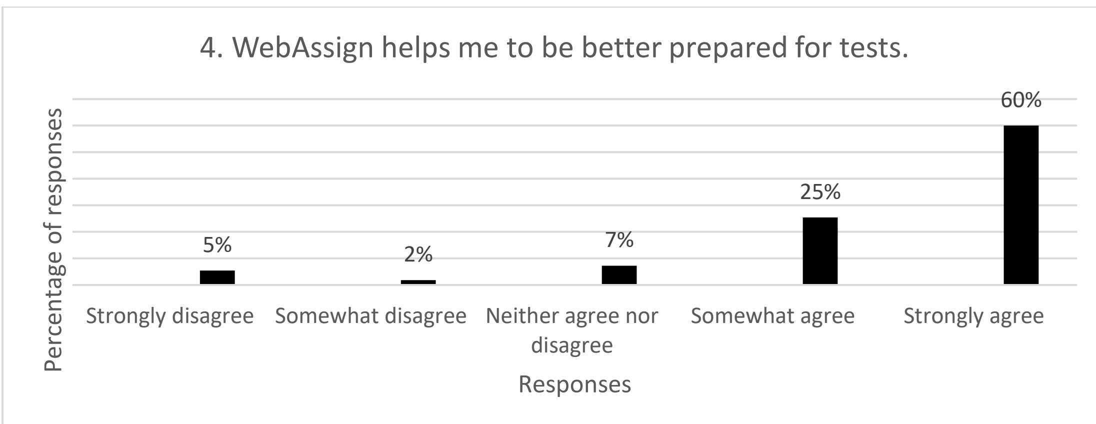


Figure H-4. Percentage of student responses to survey question

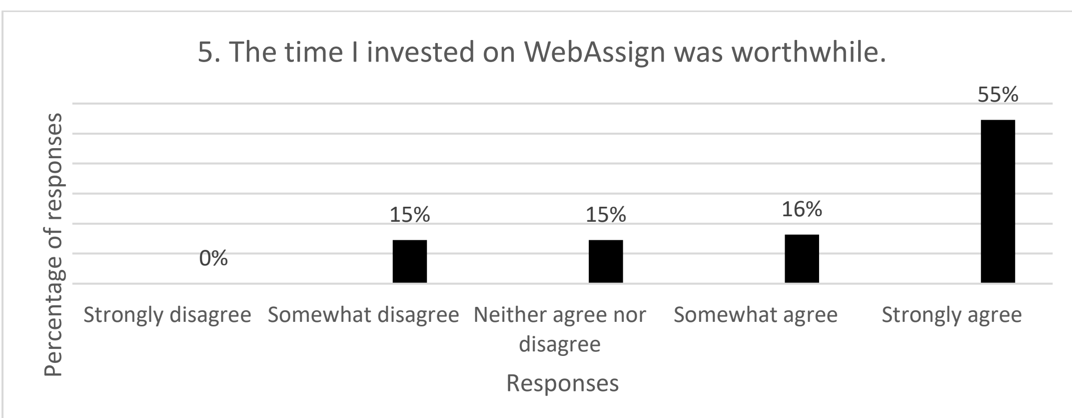


Figure H-5. Percentage of student responses to survey question

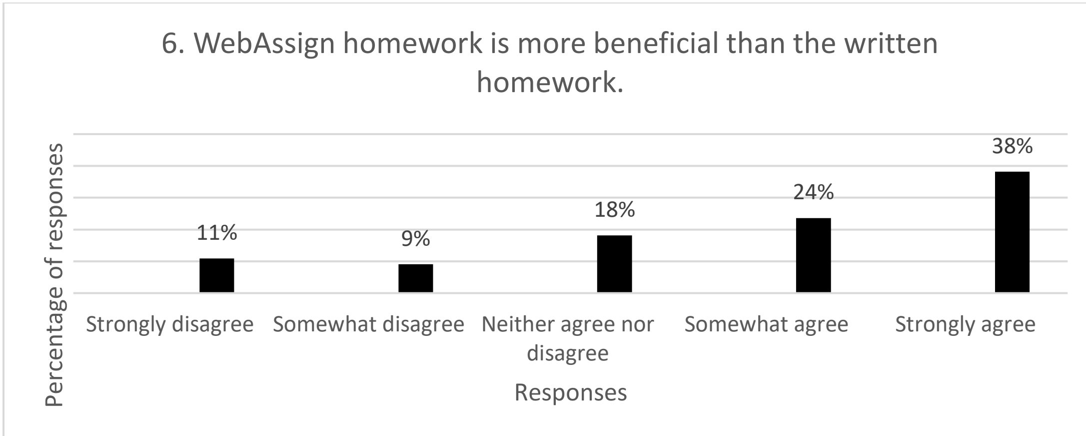


Figure H-6. Percentage of student responses to survey question

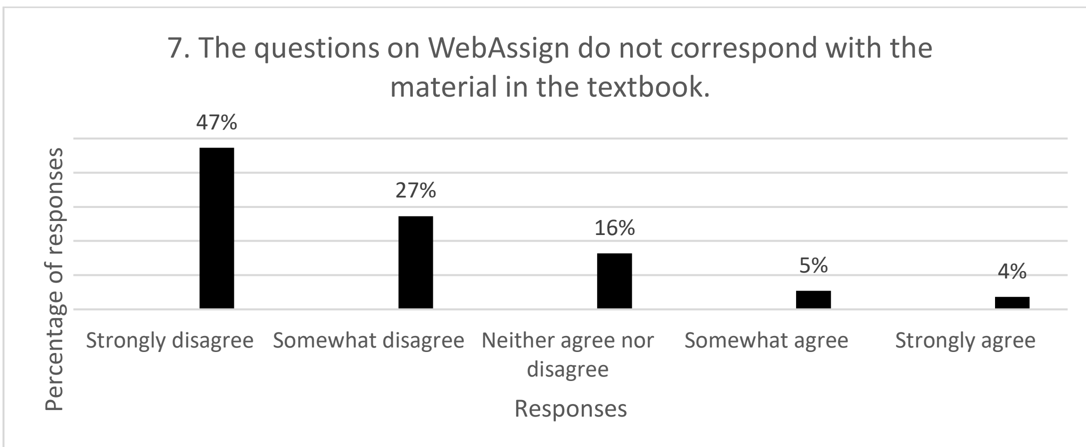


Figure H-7. Percentage of student responses to survey question

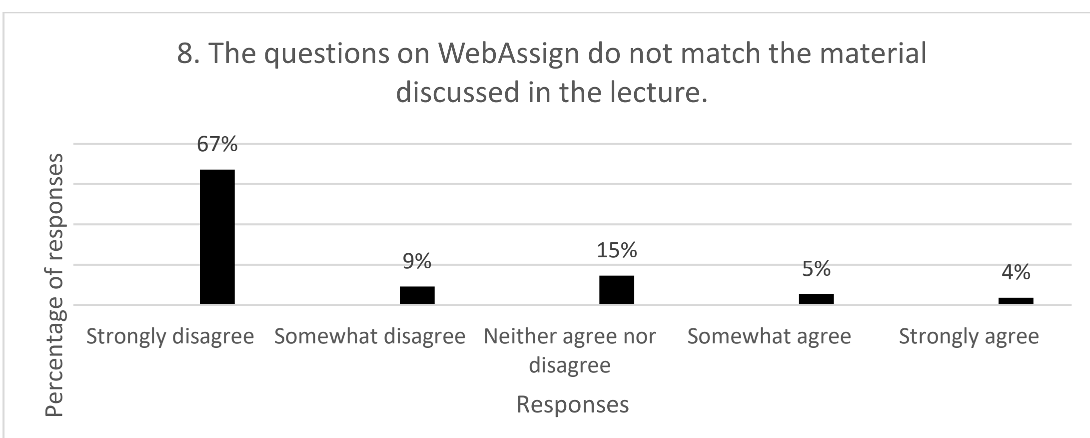


Figure H-8. Percentage of student responses to survey question

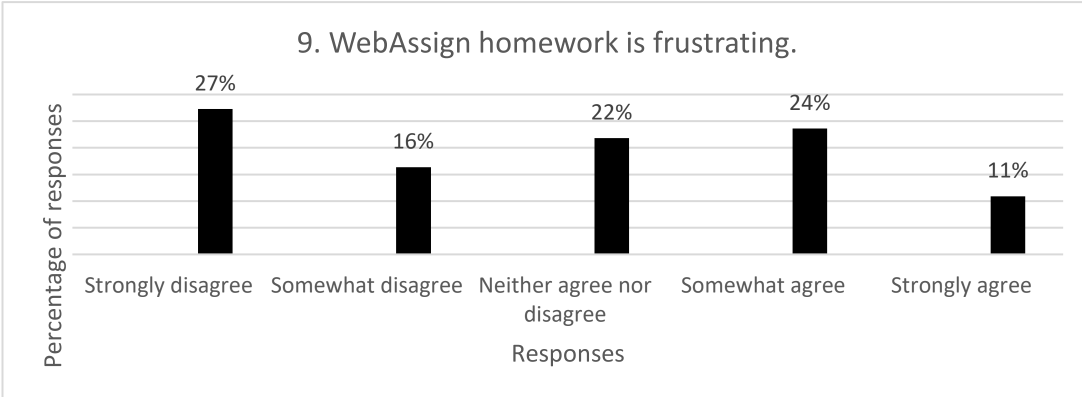


Figure H-9. Percentage of student responses to survey question

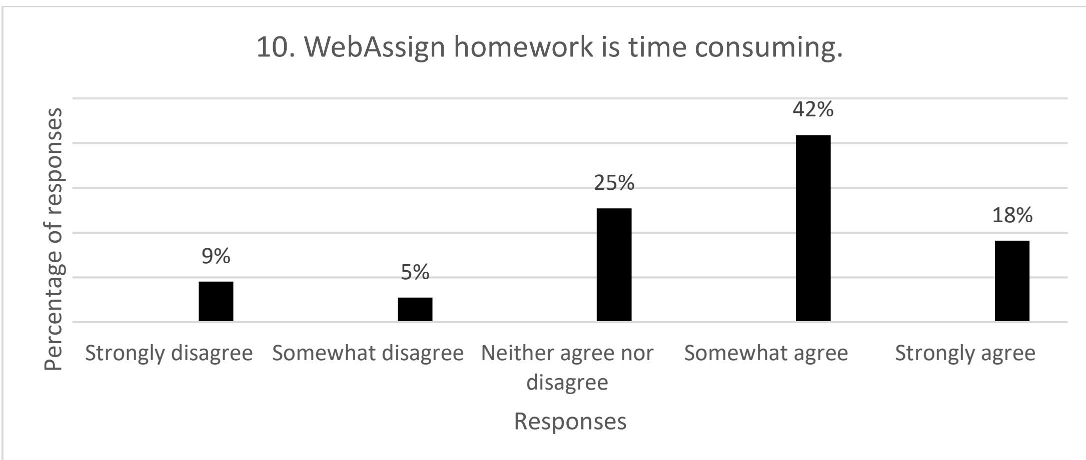


Figure H-10. Percentage of student responses to survey question

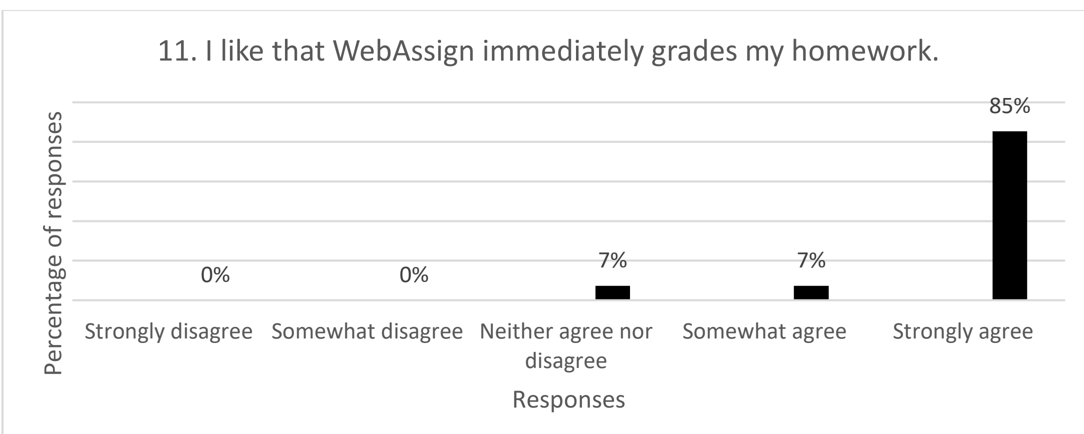


Figure H-11. Percentage of student responses to survey question

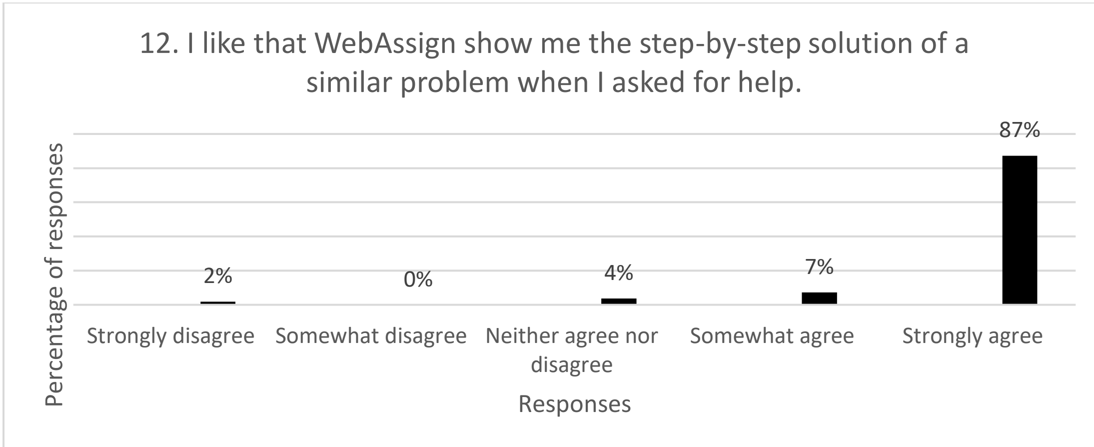


Figure H-12. Percentage of student responses to survey question

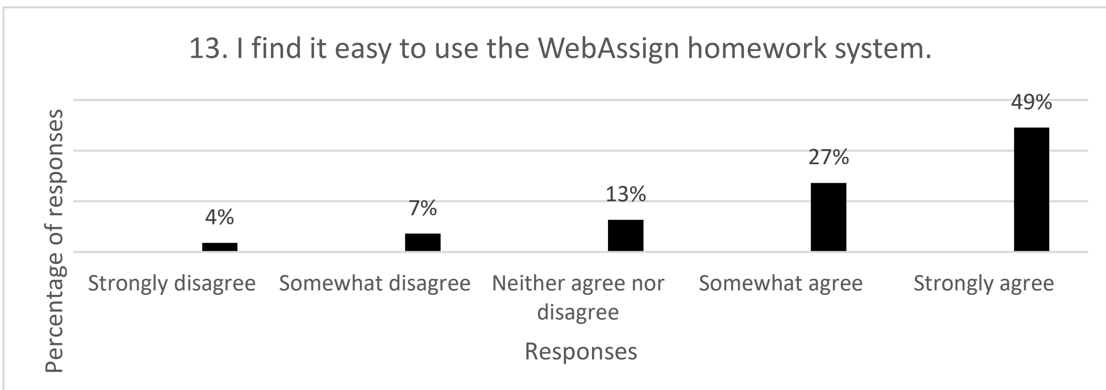


Figure H-13. Percentage of student responses to survey question

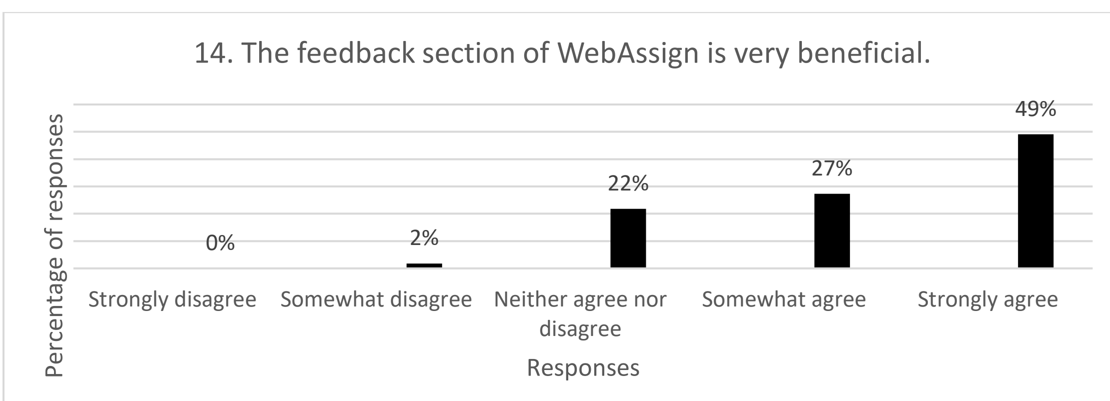


Figure H-14. Percentage of student responses to survey question

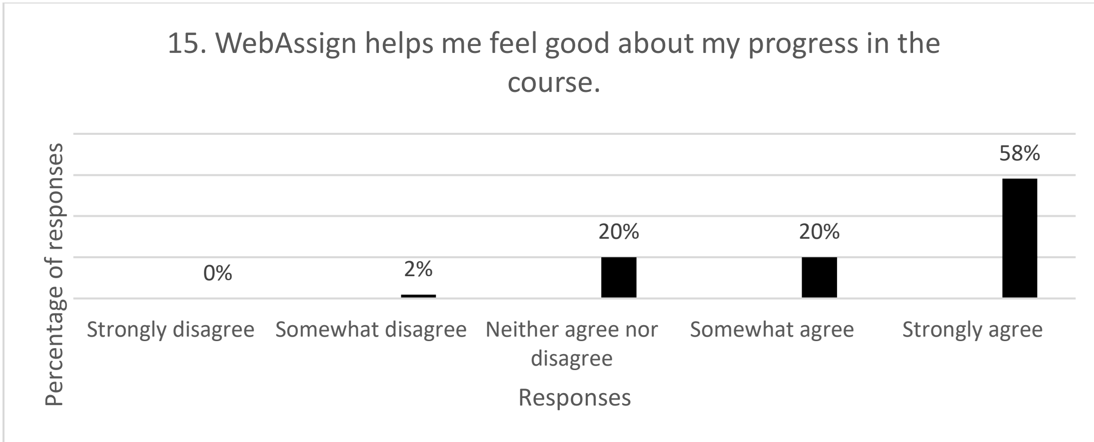


Figure H-15. Percentage of student responses to survey question

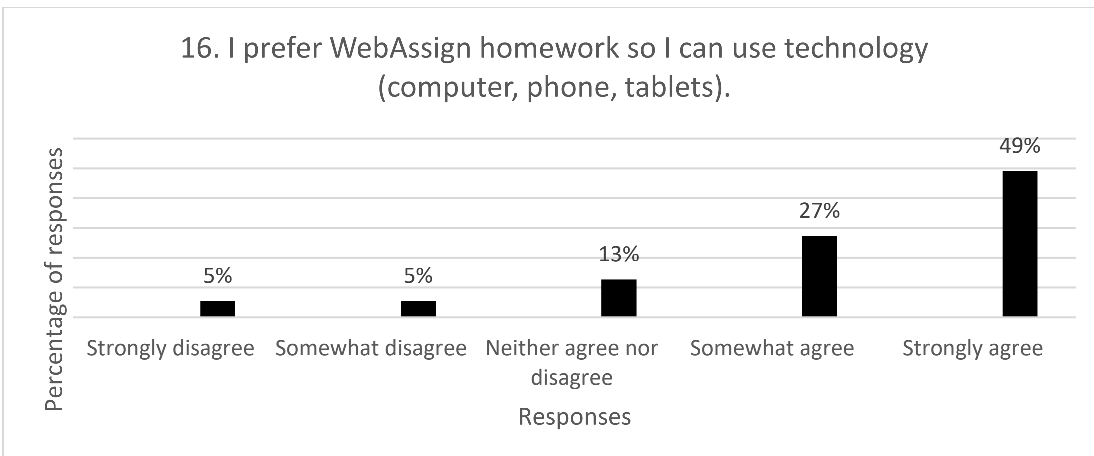


Figure H-16. Percentage of student responses to survey question

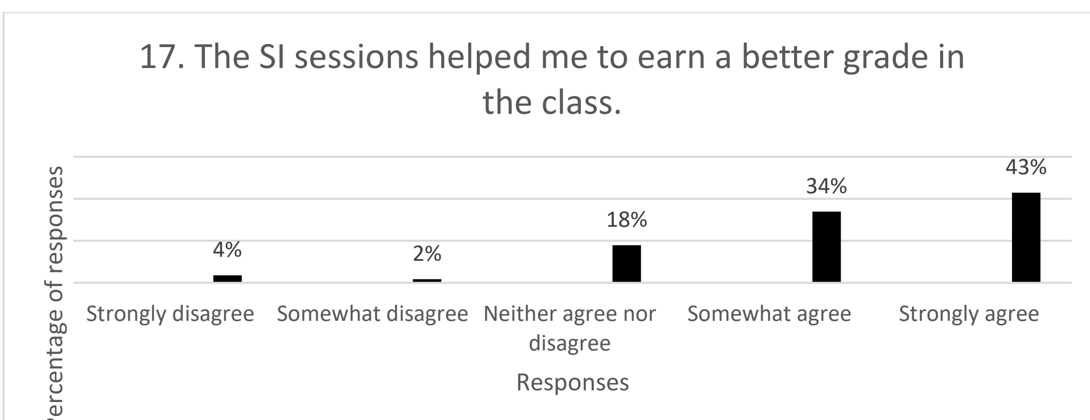


Figure H-17. Percentage of student responses to survey question

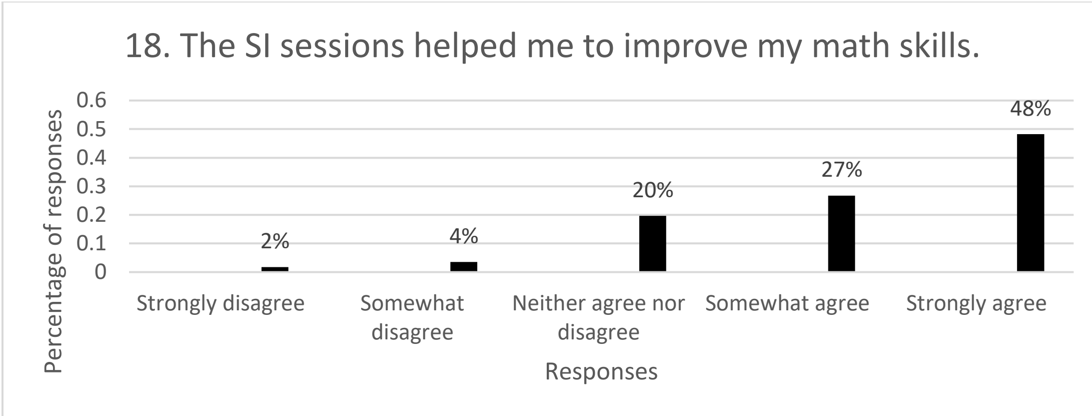


Figure H-18. Percentage of student responses to survey question

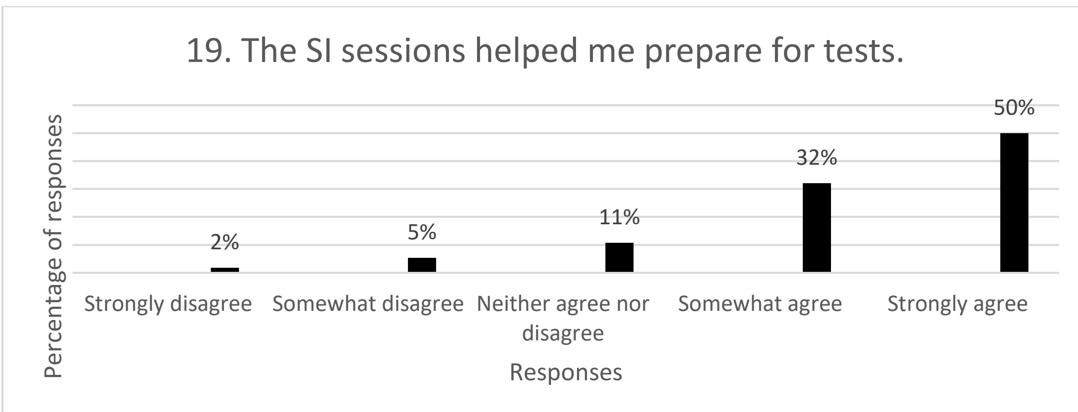


Figure H-19. Percentage of student responses to survey question

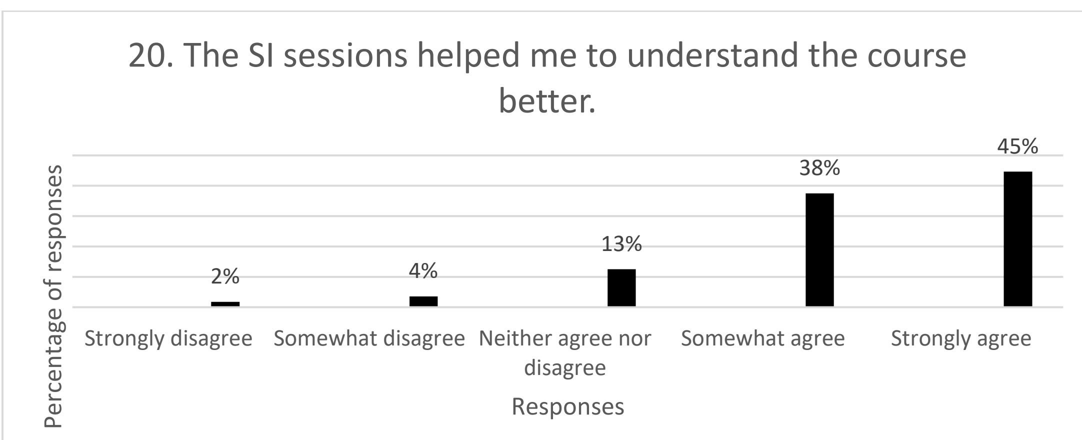


Figure H-20. Percentage of student responses to survey question

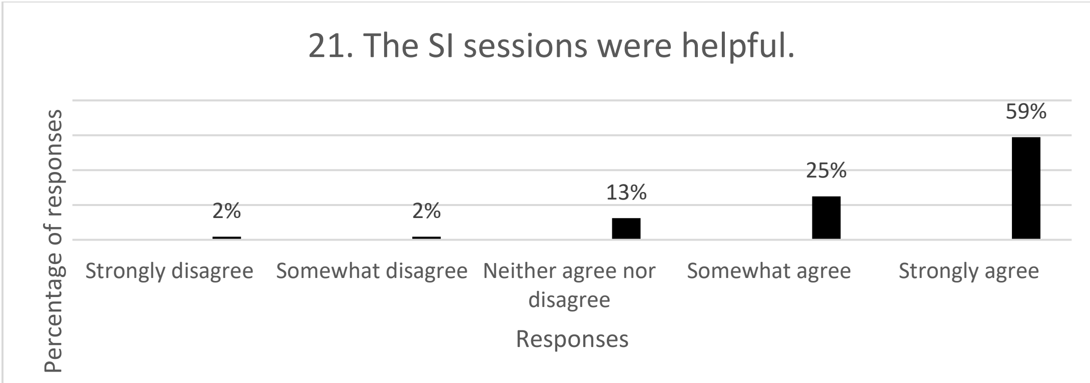


Figure H-21. Percentage of student responses to survey question

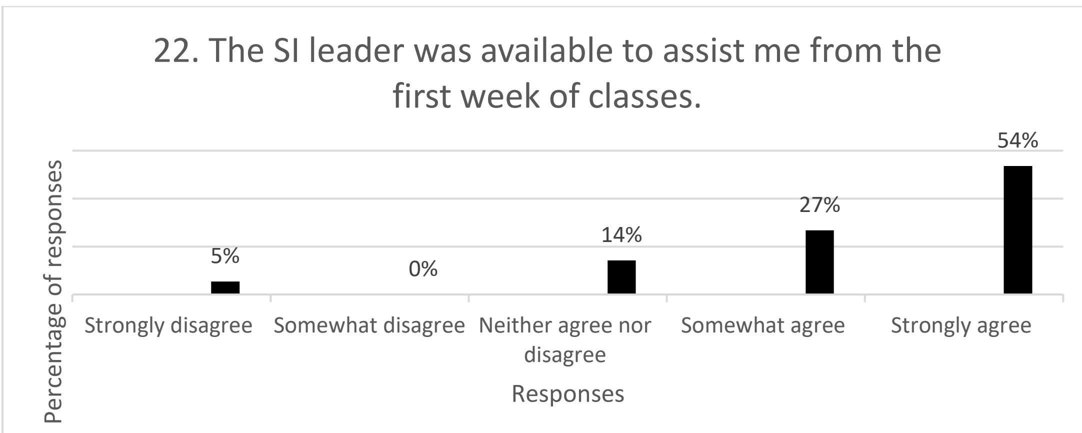


Figure H-22. Percentage of student responses to survey question

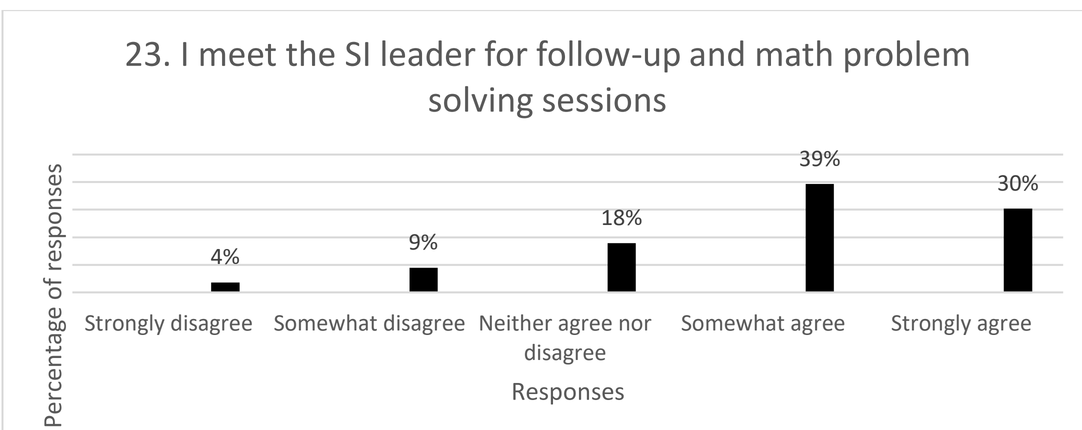


Figure H-23. Percentage of student responses to survey question

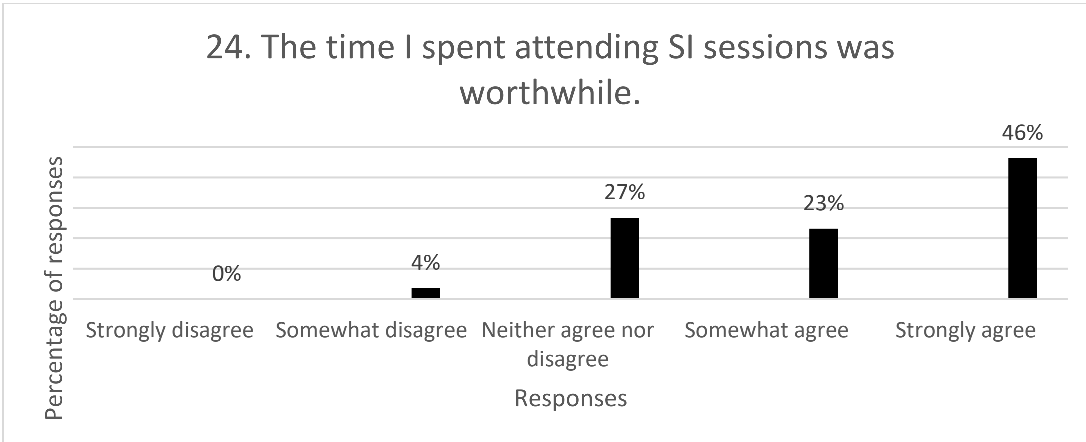


Figure H-24. Percentage of student responses to survey question

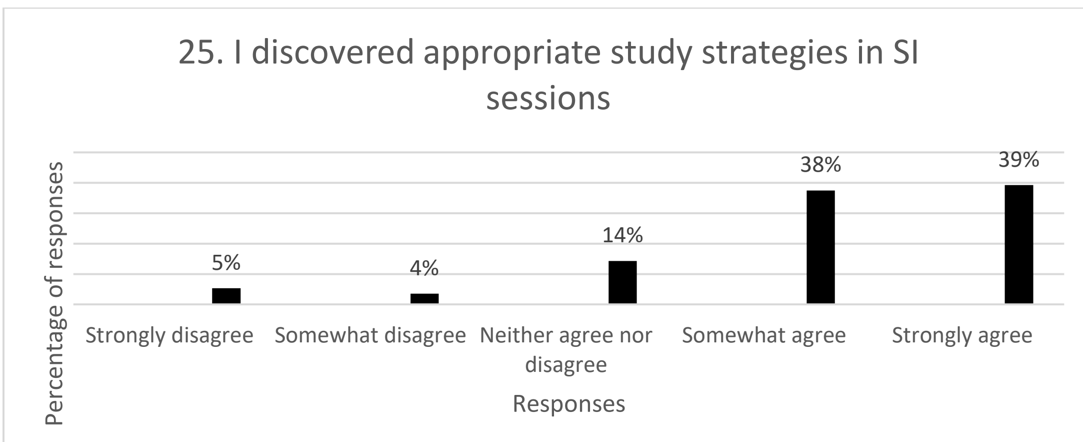


Figure H-25. Percentage of student responses to survey question

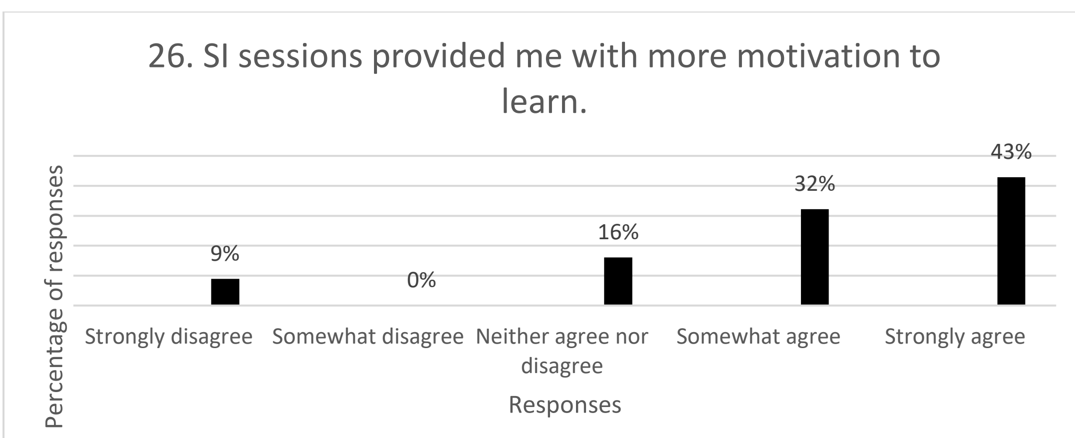


Figure H-26. Percentage of student responses to survey question

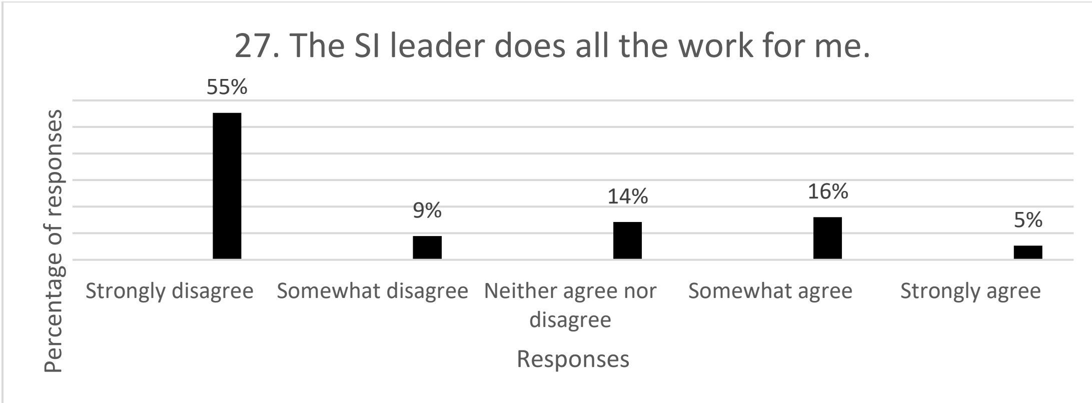


Figure H-27. Percentage of student responses to survey question

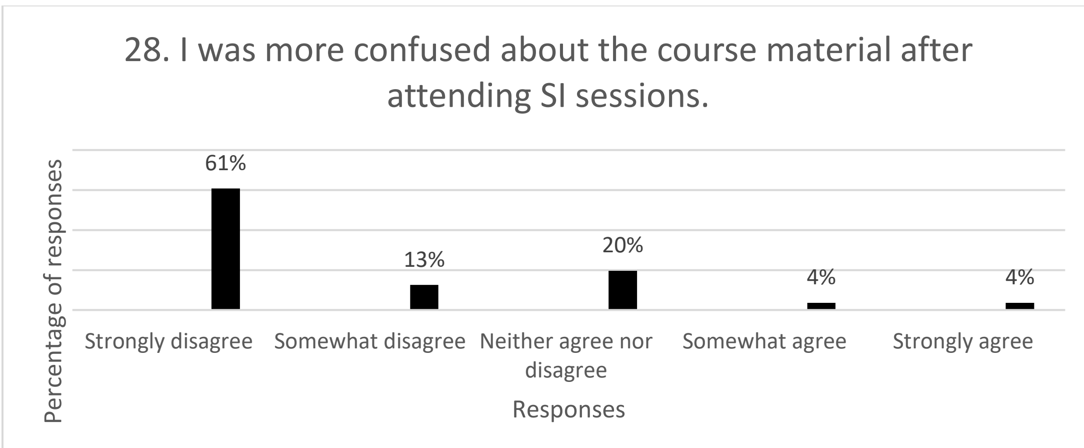


Figure H-28. Percentage of student responses to survey question