Promoting use of effective learning strategies in a college chemistry course through structured course assignments
by Rita Torrisi Rozier

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Education in Education
Montana State University
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Abstract:
Demographic analysis showed that statistically significant gender differences occurred among students in the non-treatment group so that women earned higher scores in homework and labs while men earned 9.65% fewer A and B grades, 6.16% more C and D grades, and 3.49% more F and W grades than women in their group or men and women in the treatment group. There were also indications that mid and low range students in the treatment group tended to get higher overall grades and passed the course at a higher rate than students in the non-treatment group, but these findings were not statistically significant and so were inconclusive. However, the numbers are compelling in that the treatment group had 6.5% more B grades, 5.2% fewer C grades, and a 2.3% higher pass rate than the non-treatment group.

In addition, the findings tend to agree with homework research data, showing that students beyond middle school age benefit in terms of learning from homework (Cooper et al, 1990), and with Supplemental Instruction data that support peer learning through use of study strategies (Martin, 1998). The particular pattern of a lower withdrawal rate and increased success for mid-range students of the treatment group (more B’s and fewer C’s and withdrawals) agree with SI data, but the gender-related aspect may be unique.

In regards to the second research questions, the comparison of pre- and posttest results for the Learning and Study Strategies Instrument (LASSI) and qualitative interviews with students indicated that the treatment did not affect students’ use of learn strategies or metacognitive awareness of them. This is also in keeping with previous findings that assimilation of learning strategies occurs when students are made explicitly aware of them and encouraged toward metacognitive oversight of their own learning. Given that the modeling and feedback components of the research plan were not fully implemented, these findings were not surprising.

The answer to the remaining qualitative question, in terms of ease of use and cost, was the use of structured homework assignments manageable from the instructor's perspective, remains debatable. From his experience with the research and prior to learning the answers to the first two questions, the instructor said that he was unlikely to continue the investment of time and effort necessary to create homework assignments and answer keys. However, there was no financial cost and during the subsequent semester of chemistry, he implemented a modified program of structured homework assignments, reducing the emphasis on group work and using assignments from the book as needed. Other instructors may be open to alternative formats that encourage the functional elements of peer learning and the use of SGCP strategies and that provide modeling and feedback on the use of strategies.

Recommendations Despite the complexity of the research findings, the consistency of success of students who participated in the treatment group speak to its efficacy in assisting students to learn and to persist. The initial research model was based on educational programs of instruction and literature
that indicate that learning can be enhanced at the college level by promoting use of study skills, group interaction, and attention to how to learn. The particular format followed in the current research lacked elements of structure that would likely have enhanced student learning and its observable effects. According to the review
PROMOTING USE OF EFFECTIVE LEARNING STRATEGIES IN A COLLEGE CHEMISTRY COURSE THROUGH STRUCTURED COURSE ASSIGNMENTS

by

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Education in Education

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APPROVAL

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This dissertation has been read by each member of the dissertation committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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CHAPTER I
INTRODUCTION

Educating a diverse population of entry-level college freshmen in a demanding course is a multifaceted endeavor. Initially, both instructors and students face the challenge of reaching a "consensual domain" regarding academic discourse. The establishment of a consensual domain, defined as the cooperative development of a common frame of reference for linguistic interactions (Maturana & Varela, 1980), reduces the subjectivity of understanding and assists people of diverse backgrounds to communicate more efficiently and fully. A second challenge for instructors involves finding a method and rate of instruction that allows students optimal assimilation of new vocabulary and concepts. Traditionally, the failure of some students to keep pace with the instructor and class has been viewed as a function of the student's cognitive facility and application of effort (Vygotsky, 1978). However, since the Higher Education Act of 1965, there has been official recognition in the United States that students' success within the college classroom is intrinsically linked to a variety of factors, some of which are only peripherally related to innate cognitive ability or effort (Muraskin, 1997). As an example, students who enter college with existing knowledge of culture and vocabulary linguistically similar to the consensual domain have an obvious advantage over students who are less familiar with the discourse used in college classrooms (deMarrais & LeCompte, 1999; Wertsch, 1998). Additionally, there is evidence that some students lack knowledge of effective learning strategies and their use (Boyer, 1987; Najar, 1999; Palincsar & Brown, 1984; Wertsch, 1998).
Research has shown that the failure of students such as these can be attributed in varying degrees to environmental factors beyond individual control (Bandura, 1997; Department of Health and Human Services (DHHS), 2000; Vygotsky, trans. 1978). Lack of control and the perception of a lack of control over the ability to learn directly affect motivation (Bandura, 1997; Maddux, 2002; Seligman, 1990). In his studies of self-efficacy, Albert Bandura found that, "Unless people believe they can produce desired effects by their actions, they have little incentive to act" (1997). Reduced incentive severely limits student outcomes in higher education where student persistence affects conscious decisions such as whether to enroll, where to enroll, how to fund, and what major to pursue and courses to take, and less conscious decisions involved in daily choices regarding actions, thought processes, and the amount of effort students put forth (Bandura, 1997; Boyer, 1987; McKeachie, 1986). As research has identified environmental factors affecting efficacy and learning, schools have taken increasing responsibility for providing instruction that transcends limitations in students' academic preparation (DHHS, 2000). At the college level, community and junior colleges prioritize the quality of teaching and provide a graduated entry to the more rigorous coursework of four-year colleges for urban students (Boyer, 1987). In rural states such as Montana, students have fewer options for higher education. At Montana State University-Bozeman, where freshmen range from high school salutatorians to provisional admits who fail to meet the admission criteria*, many instructors feel they have no choice but to "dumb

* Admission criteria for traditional-age students at Montana State University-Bozeman are: Diploma from accredited high school with GPA of 2.5 or above, or rank in upper half of class, or GED; ACT composite score of 22 or SAT of 1030 or higher; and successful completion of a H.S. curriculum that included 4 years of English, 3 years of math and social studies, 2 years of lab science, and two years of other approved coursework. Admission criteria are waived for non-traditional age students.
down" freshman courses, reducing and easing course content or artificially raising grades to allow more students to pass (Trout, 1999). In the more challenging courses, alternatives to "dumbing down" or curving grades are failing an unusually high proportion of students or assisting poorly prepared students to keep pace with their class. For political, practical, professional, and ethical reasons, educators prefer to see their students keep pace.

Early in the 20th Century, Lev Vygotsky (trans. 1978) investigated factors that affect variability among students in classroom performance. His work and subsequent studies by his students with the "zone of proximal development" (ZPD) showed that the "intelligence" of students, defined here as their ability to learn, was more likely to be underestimated in terms of potential to assimilate learning if students were educationally disadvantaged due to social class or financial constraints than if they were of a more advantaged social class and background. Vygotsky theorized, and findings showed, that with guidance from teachers or more advanced peers, students with large ZPDs (those whose ability had been underestimated) were able to reach a level of learning comparable to more highly rated students with smaller ZPDs (those whose instruction kept pace with their intellectual development). In addition to discrete units of information, Vygotsky's disadvantaged learners assimilated the learning strategies of their peer guides (Vygotsky, trans. 1978; Wertsch, 1998).

In a related area, Annemarie Palincsar and Ann Brown (1984) determined that reading comprehension among middle-school children was in part a function of the knowledge of, and ability to use, learning strategies. They noted that students' existing linguistic experience (or lack thereof) affected comprehension: students with low
comprehension were capable of decoding written texts but were unable to distinguish the relative value of details versus concepts, conduct a meaningful dialogue regarding the main ideas, or effectively summarize material (Palinscar and Brown, 1984; Palinscar, Brown & Campione, 1993). Practitioners had identified strategies necessary to effective reading and reasoning as those of "questioning," "summarizing," "clarifying," and "predicting," but had not been successful in introducing them to students in a manner that caused them to understand and appropriate the strategies (Wertsch, 1998). The Palinscar and Brown method, called Reciprocal Teaching, was highly successful in encouraging students to appropriate strategies, resulting in significant and lasting improvement in students' intermental functioning Palinscar & Brown, 1984; Wertsch, 1998), or internal use of socially acquired understanding (Vygotsky, 1978).

Another and very similar method, Supplemental Instruction, was introduced by Deanna C. Martin at the University of Missouri at Kansas City (UMKC) in 1973 to assist learners in historically difficult college courses. Both Reciprocal Teaching (RT) and Supplemental Instruction (SI) used teacher- or advanced student-led groups of students to identify and use learning strategies that encourage individuals to summarize, generate questions, clarify, and predict. Both credit their success to a combination of emphasis on strategy and the social role-playing method by which the strategies are taught: when placed in the role of teacher, students are motivated to act the part.

Additionally, both methods address the concern noted by some educational researchers (Dimon, 1988; Keimig, 1983) that it is difficult to teach transferable learning skills in isolation from educational content. Both also utilize a step in learning that is often overlooked but is considered essential by Albert Bandura (1997) and Lev Vygotsky
(trans. 1978), in that desirable behaviors should be modeled for learners and the modeling attended by learners. Vygotsky further postulated that "doing" proceeds "knowing," thereby giving further credence to the portion of RT in which students parrot teachers' words before recognizing the value of the particular words chosen—a value that differentiates between concepts and supporting details of those concepts. Although the methods target completely different groups of learners, in that RT is used primarily with elementary and middle-school students who are resistant to usual methods of learning to read, and SI with college students enrolled in historically challenging courses, the intent, methodology, and results are remarkably similar and impressive. A third similar method, Learning to Learn (LTL), predates both RT and SI in that it grew from research conducted during the 1960's, and has been used with success in post-secondary education, adult education, and business formats (Heiman & Slomianko, 1988). All three methods earned wide respect and are currently (RT and SI), or have been (LTL), endorsed by the U.S. Department of Education (DHHS). However, despite the proven effectiveness of Supplemental Instruction at the college level (UMKC, 2000; see also Smith & MacGregor, 1992) and concerns regarding retention and graduation rates, many universities, including Montana State University-Bozeman, do not use SI. Although SI was developed to reduce the expense of one-to-one tutoring (Smith and MacGregor, 1992), cost is a principal drawback to its use, as is the organizational effort required, including personnel, training, assessment, and supervision.

Organizational effort has been a deterrent to collaborative approaches to education in general (McKeachie, 1994; Smith & MacGregor, 1992). While lauded for its role in encouraging creative, higher-level thinking in rich and challenging contexts,
collaborative, small-group learning has been associated by some with administratively complex and time-consuming projects in which assessment is viewed as subjective and somewhat dubious (McKeachie, 1994; Smith & MacGregor, 1992). On the other hand, SI, RT, and LTL represent collaborative learning programs that occur in addition to or outside of required coursework and which may also be administratively complex and expensive. The current research was undertaken to investigate an alternative, simpler approach to achieve results similar to SI but with the following considerations:

1. Students must be encouraged to use the effective learning strategies of questioning, summarizing, clarifying, and predicting in a social learning context.

2. The instructor should retain the locus of control over the content of the learning materials, but not be burdened with complex, costly, or time-consuming preparations.

3. Rather than replacing course components, the learning materials should be supplemental, complementary, and assist students in learning required material and in assimilating effective learning strategies.

Statement of the Problem

The problem is that students in challenging freshman-level science courses have diverse levels of preparation and understanding of how to learn difficult content and college instructors do not have manageable, effective ways to induce students to use learning strategies that are proven to promote learning.
Statement of the Purpose

The purpose of the experimental study was to investigate structured course assignments versus unstructured assignments in relation to students' assimilation of learning strategies and measures of learning outcomes. In addition, the study provided a format for qualitative investigation of the manageability of structured course assignments from the instructors' perspective regarding ease of use and cost, and students' attitude towards and use of learning strategies.

Research Questions

1. Are there significant differences in measures of students' learning outcomes between the treatment group in which homework assignments were structured to induce use of learning strategies and those of the untreated group whose homework assignments were not specially structured?

2. Are there significant differences in pretest-posttest scores between the treatment group and the non-treatment group on measures of attitude and use of learning strategies?

3. Are the experimental strategies manageable from the instructor's perspective in terms of ease of use and cost?

4. Do students gain in understanding of learning strategies by completing course assignments that are structured to encourage their use?
Important of the Study

Administrative concerns regarding the retention of college students and student concerns regarding the rising costs of higher education have led to increased scrutiny of student success within the classroom. While factors regarding teaching are addressed in faculty training, tenure, and research, less organized attention is directed toward student use of learning strategies. The current research is of interest because it investigated a modification of a common component, course assignments, to assist college instructors to induce freshmen-level students to use learning strategies that have proven successful in a variety of alternative contexts. A research project on this topic has the potential to be beneficial on several levels with regards to learning, teaching, and retention:

1. As with Supplemental Instruction, incoming freshmen of diverse backgrounds could be led to incorporate efficient and effective learning strategies, leading to increased learning and persistence in difficult courses, higher GPA’s, less need to repeat courses, and greater overall persistence in college (UMKC, 2000). Like SI, the results may be expected to be effective for disadvantaged, non-traditional, and minority college students.

2. Instructors may find the research assists them to lead learners toward greater independence and success in learning through revised course assignments.

3. On an institutional level, the research has the potential to assist with retention efforts, affecting institutional finances and the responsibility to help students reach their educational goals.
4. The importance of self-directed learning at the college level is under-represented in research on student acquisition or use of study skills and in the potential for homework assignments to direct the ways in which students learn. Therefore the research has the potential to direct more attention on these neglected areas.

Definitions

Consensual domain: The conscious effort of individuals to search beyond their personal cognitive understanding of terms, phrases, and concepts to a socially shared understanding of meaning results in the development of a common frame of reference, or consensual domain, that assists in functional communication during linguistic interactions (Maturana & Varela, 1980).

Critical Thinking: Critical thinking is a process of reflection that involves identifying and challenging assumptions, consideration of context, analyzing and synthesizing alternatives, and engaging in reflective skepticism (Brookfield, 1987).

Cultural Tools: Learning is contextual in that the cultural tools of language and knowledge developed by others are passed on to learners in a manner that provides a basis for individual achievement (Vygotsky, 1978). James Wertsch provided a multiplication problem as an example of a cultural tool, suggesting readers multiply 345 by 762 with just paper and pencil. Most people, he asserted, would use a vertical format to solve the problem without recognizing their dependence on the format. That format is a cultural tool, best recognized in its absence (Wertsch, 1998).

Efficacy: Efficacy is defined as one’s belief in his or her ability to accomplish desired outcomes (Bandura, 1997).
Perceived self-efficacy: An individual’s expectation of success in attaining goals as a result of organized personal effort is defined as perceived self-efficacy (Bandura, 1997). People have both general and specific efficacy beliefs that may be constantly revised as a result of personal experience and social feedback (Bandura, 1997; Seligman, 1990).

Learning Strategy: Cook & Mayer (1983) classify strategies that facilitate learning into three groups: task-limited, goal-limited, and general strategies or higher-order strategies that regulate the use of the first two. All three are necessary to learning, but for the purposes of clarity, in this document, the term “learning strategy” will be defined as a sequence of behaviors that learners purposefully engage themselves in and direct through metacognition to acquire knowledge and construct meaning from new material while integrating it with prior knowledge and understandings (McKeachie, 1986; Paris, Lipson, & Wixson, 1983; Weinstein & Palmer, 2002).

Metacognition: The process of being aware of, thinking about, and directing one's own thinking for the purpose of monitoring and regulating it toward a desired end is termed metacognition (Conti and Fellenz, 1991; McKeachie, 1986). Studies such as one by Paris, Lipson, and Wixson. (1983) suggest that one's attitudes and beliefs are involved in the metacognitive process.

Reciprocal Teaching: Reciprocal teaching refers to the set of instructional activities that encompass a socially structured dialogue between a teacher or advanced peer and a small group of students. The teacher or peer models the use of all or part of the four target strategies of summarizing, question generating, clarifying, and predicting that are used to assist in constructing meaning from text. An essential part of the strategy involves the
social interaction that occurs when students assume the role of teacher and lead the
group dialogue, getting as little or much assistance as necessary from the teacher
(Palinscar, 1986; Wertsch, 1998).

SGCP: The initials, SGCP, are used in this document to refer to the summarizing,
generating questions, clarifying, and predicting behaviors used in each of the
teaching/learning methods Learning to Learn, Supplemental Instruction, and Reciprocal
Teaching. The individual concepts defined below are, unless otherwise noted, from
Palinscar and Brown’s model for Reciprocal Teaching developed in 1984:

Summarizing is verbal or written identification of the most important
information of a sentence, paragraph, or passage. Summarizing requires students
to identify and integrate concepts from text or lecture, and communicate them in
a succinct, understandable form.

Question generating reinforces the summarizing strategy and assists in
comprehension through reflection and metacognition. To generate questions,
students evaluate information to see if it provides substance for a question, then
reword it in question form, and self-test or test peers. Question generating
involves students in discovering what they don’t know, need to know, or would
like to know about a concept, and can be used in mastery learning or to infer or
apply new information from text, leading to the formulation of hypotheses
(Palinscar, 1986).

Clarifying is a learning strategy particularly helpful for students who have
difficulty comprehending text. These students may not be uncomfortable when
words or passages are not making sense. When students are asked to clarify,
they are forced to attend to the causes of the textual difficulty such as new vocabulary, unclear reference words, and unfamiliar or difficult concepts. The conscious act of clarifying teaches students to recognize potential barriers to comprehension and to take the necessary measures to restore meaning through reading, dialogue, or reasoning. Further, clarifying emphasizes that the goal of learning is to construct meaning from new material (Palincsar, 1986).

Predicting: In Reciprocal Teaching, predicting occurs when students hypothesize about what an author will write next by considering what they already know. Predicting motivates students to learn if the text will confirm or disprove their hypotheses, and helps them to link new knowledge with knowledge they already possess. The predicting strategy facilitates use of text structure regarding headings, subheadings, and imbedded questions (Palincsar, 1986). In Supplemental Instruction, predicting is less formalized, but assists with the integration of how-to-learn strategies with what-to-learn by helping students attend to an author's or lecturer's textual construction.

Supplemental Instruction: Supplemental Instruction (SI) was originally developed by Deanna C. Martin, University of Missouri-Kansas City, in 1973. SI is now a formalized and commercially marketed technique documented by the U.S. Department of Education to be effective in assisting student learning in historically difficult college-level courses. It involves four key people or groups (UMKC, 2002):

1. An SI supervisor trained at UMKC in SI identifies courses, gains faculty support, selects and trains SI leaders, and monitors and evaluates the program.
2. Faculty members who teach historically difficult courses may choose to invite the SI supervisor to organize support sessions for their class. In doing so, they agree to screen and select peer leaders for competency in course content.

3. SI peer leaders are students selected for course competency and trained in proactive learning and study strategies. They attend course lectures, take notes, read assigned materials, and conduct three to five out-of-class SI sessions a week, modeling behaviors that help students to integrate course content and learning strategies. SI leaders are paid hourly stipends or through staff release time, work study funds, or fee waivers.

4. Students who choose to participate in SI out-of-class sessions are the fourth component of the SI network. They take turns leading the group in each of the four activities of summarizing, clarifying, generating questions, and predicting under the direction of a peer leader. (UMKC: [http://www.umkc.edu/cad/SI/Sidocs/SIoverviewdoc.htm](http://www.umkc.edu/cad/SI/Sidocs/SIoverviewdoc.htm))

Zone of Proximal Development (ZPD): Lev Vygotsky suggested this term in the 1930's as part of his genetic account of development. It refers to a range of potential learning of an individual in which the bottom of the zone is defined by a level of testing or accomplishment that the individual can attain without assistance and the top is that which can be attained with guidance and assistance from advanced peers or instructors. Vygotsky showed that learning takes place within the zone and is mediated by the social environment that provides cultural tools and semiotic signs (Vygotsky, trans. 1978).
Brief Overview of the Methodology

The research approach to the first two questions involved quantitative evaluation of the effectiveness of structured course assignments in promoting learning and in eliciting use of learning strategies, followed by qualitative assessment of the manageability and effectiveness of their use. Mixed methodology was chosen so that:

1. Quantitative measures could establish whether homework assignments could provide adequate structure to replicate the benefits of traditional Supplemental Instruction; and,

2. Qualitative methods could establish the dimensions of the context in which assignments might be of value and the ways the structure might be altered to increase its value to participants.

The course, General Chemistry I, was chosen because it met the SI criteria of being an historically challenging course with a high rate of failure and withdrawal at Montana State University-Bozeman. The primary experimental component measured learning outcomes between the treatment and non-treatment groups, including test scores, course grades, and the percentage of students who pass the course. A MANOVA followed by i-test comparisons and chi squares were the primary statistical tools. The same experimental treatment was also measured in relation to students' perceptions of their study skills and attitudes, using pre- and posttests of a commercially available instrument, the Learning and Study Strategies Instrument (LASSI). The LASSI was given to three stratified cluster samples from each group of students, those who were given structured homework assignments during the semester, and those who were not. The qualitative
portion of the research was designed to investigate the ease of use of the structured assignments from the instructor's perspective and the degree to which students expected to incorporate learning strategies into future coursework.

The between-groups measures arose from potential differences in learning between students in the Tuesday/Thursday labs whose homework was less structured, and those in Wednesday/Friday sections, whose homework assignments were more highly structured. The structure was comprised of two elements: wording of problems using language specifically designed to invoke summarizing, question generating, clarifying or predicting (SGCP) responses, and the strong suggestion to work on homework in groups of two or more. The qualitative research component consisted of observation throughout the term, and individual and focus-group interviews that sought feedback from the course instructor, teaching assistants, and students. The instructor, teaching assistants, and focus-group interviews were recorded and transcribed to facilitate accurate interpretation of results and use of quotes. Individual student interviews were conducted by telephone following the term and were not recorded. Results were analyzed for content of response patterns with attention to chronology, key events, processes, and issues (Patton, 1990).

Assumptions, Limitations, and Delimitations

Assumptions

The following assumptions support the design of the proposed research:

1. Students will do their own work, as an individual or with a study partner, in the required SGCP activities: In addition to turning in assigned work, the concern that
students perform the work themselves will be monitored through the qualitative portion of the research (see Appendix B).

2. Chemistry 131 is a course with room for improvement in student test scores. As in SI, this course was chosen because it represents an historically difficult course at MSU-Bozeman, in which a significant number of students drop out or fail, and where instructors are known to curve grades to achieve adequate success rates among students. According to records kept by the Dean of Students at MSU, for some years Chemistry 131 has had the lowest student success rate, or highest rate of withdrawal and failing grades, for entering freshmen at MSU-Bozeman.

3. The results of the research can be inferred to apply to other populations of college students. Due to research limitations and the particular course chosen, inference will be limited to college students enrolled in historically difficult college courses that rely on homework for student learning. However, since SI has been used successfully in a variety of course styles, further research is indicated.

A final assumption of the research is that the order of SGCP activities is flexible and that the modeling and social learning components can be provided through a combination of written and oral instruction and informal group interaction. Both RT and SI have been adapted to a variety of circumstances with reasonably consistent results. In planning the research, attention was given to identifying and preserving the essential elements of SGCP that assist learning while adapting to the instructor’s course design. Since ease of implementation is essential to future use of the SGCP by instructors, flexibility of design will be necessary.
Limitations

The population of students who were given more highly structured homework assignments (the test measure) were one half of all students who enrolled in either of two lecture sections of the experimental course, an historically-difficult freshman-level course in college chemistry. Students self-enrolled in lab sections that contained a mix of students from each lecture; students in Wednesday/Friday labs were chosen by a toss of a coin to receive the experimental treatment, and those in Tuesday/Thursday labs to serve as the control. All students were expected to meet the course prerequisite of two years of high school math to include Algebra, or an ACT score of 25 or higher, SAT score of 570 or higher, or completion of Math 105, Algebra for College Students. Students' were able to enroll whether or not they met prerequisites, but the mere existence of prerequisites was thought to limit student enrollment somewhat to mathematically-capable incoming freshmen and students who have come up through the ranks of math courses at MSU-Bozeman. In addition, the study-skill pre-test gave a measure of equivalence between the two groups.

As with Supplemental Instruction, the results may not apply to all students, but in this case to students in historically difficult college-level courses with problem-based homework assignments. In regards to the ease-of-use aspect of the structured homework, the college chemistry course follows a common science format and may therefore provide an accurate assessment of transitional issues.
Delimitations

General chemistry was chosen as a focus for the research because, as an historically difficult course offered to freshmen, it fit the profile for comparison to other studies involving Supplemental Instruction. MSU-Bozeman was chosen for researcher convenience, but also to represent a medium-sized land-grant institution with typical student success rates and financial concerns. A freshman-level course was chosen due to institutional retention concerns regarding freshmen, and research that shows the greatest need for assimilation of learning strategies among college students occurs among first year students.

The design of the study allowed both within-subject and between-group measures, with random assignment of treatment in regard to lecture section, with approximately one half of the students from each in the treatment and control groups respectively. The mixed design lent strength to findings and the likelihood that meaningful inferences could be drawn. Due to research limitations and the particular course chosen, inference was limited to college students enrolled in historically difficult college courses that rely on homework assignments and student autonomy for significant amounts of learning. However, since SI has been used successfully in a variety of course styles and institutions, general implications with a broader interpretation are discussed in the final chapter.

The research was intended to determine if students' test scores are affected by the use of structured course assignments. The "structure" provides students with a model of learning strategies that encourages them to engage in behaviors of summarizing, clarifying, generating questions, and predicting in a social learning environment. The
research did not concern itself with past findings that already validate portions of the strategy. For instance, time-on-task alone has been shown to increase learning, as has modeling, study groups, and active learning strategies. Rather, the research acknowledges that each component of the desired learning strategy is proven to be successful, but addresses the need to elicit use of the strategies by students in freshman-level college courses. The qualitative portion of the research was used to relate quantitative findings to the use of the experimental strategies, and reinforce the importance of using learning strategies by students.

Summary

On entry, students of freshman-level college courses have diverse approaches to learning and diverse levels of academic preparation. Retention data show that even students who earned high grades in secondary schools may experience difficulty achieving their goals regarding grades and understanding in college-level courses, while academically disadvantaged students may find themselves particularly affected by the increased expectations of learning in college. Students experiencing academic difficulties may not easily comprehend that study skills that sufficed previously are now insufficient or know how to learn at a greater rate or depth.

The research homework structure is based on three learning-strategy based approaches that have proven effective in improving students' grades, their ability to persist, and their knowledge of how to learn. Each taught the use of an integrated series of learning strategies that included summarizing, clarifying, generating questions, and predicting in a social learning forum with tutorial modeling and oversight. One,
Supplemental Instruction, has been used with historically difficult college courses for nearly thirty years, but requires a significant investment in terms of time, personnel, and expense. Consequently, it is currently at use in only 146 colleges in this country. The current research design is an attempt to incorporate similar academic assistance and structure through course assignments in a manner that prioritizes ease of use and cost-effectiveness from the instructor’s perspective.
CHAPTER 2

REVIEW OF THE LITERATURE

Since the beginning of formal education thousands of years ago, educators have considered student learning in relation to teaching. On most college campuses today, that relationship is standardized through a dual measure of accountability and assessment, the course grade (Boyer, 1987; McKeachie, 1994), which indicates the degree of success attained through the teaching/learning contract. The learner's responsibility is to acquire knowledge and construct meaning from new material while integrating it with prior knowledge and understanding at a rate commensurate with course content (Seaman & Fellenz, 1989). The goal of the teacher is similar: to stimulate construction of meaning by students, or to impart a pre-determined body of knowledge and understanding from instructor to students within the confines of the course (Lowman, 1984; McKeachie, 1995). Despite the common objective, the interaction between teaching and learning in the college classroom is complex and imperfect, and there is often a wide disparity of success among students in achieving learning (deMarrais & LeCompte, 1999; Muraskin, 1997; Najar, 1999). Consequently, educators have investigated many strategies for classroom teaching and learning in efforts to improve the consistency of success in learning (McKeachie, 1995).

Until recent decades, the bulk of research was applied to teaching methods rather than learning strategies. Preparatory teachers are professionals who receive professional education and guidance regarding their teaching abilities, and are held accountable for the
outcomes of their teaching. They are thus intrinsically interested in improving educational outcomes (McKeachie, 1994), but generally find it easier to modify and assess their own behavior as teacher than the behavior of learners. At the college level, the same principles apply with an added twist, the perception that, given resources such as content, an imperative to learn, and adequate instruction, learning is a function of students’ cognitive facility and application of effort (McKeachie, 1994; Muraskin, 1997; Najar, 1999).

Consequently, certain trends in learning have been slighted by the research. Namely, even where improved classroom instruction has resulted in overall improvement in student outcomes at the college level, individual student learning continues to vary widely, especially among first-year students (Muraskin, 1997; Tinto, 1993). Notably, students who are high-risk in terms of persistence due to sub-optimal levels of motivation or preparation for higher education, or who have hidden or physical disabilities or low income status, tend to have lower grade-point averages (GPA's), more fluctuation in term grades, more dropped courses, and more withdrawal from higher education than students who are not at high risk (Levitz & Noel, 1995; Muraskin, 1997). Alternatively, individuals who are not considered at-risk tend to have greater stability in grades, or less deviation in course grades from their GPA, an accepted measure of student learning. That is, students who are not at-risk and who get high, medium, or low grades in a given term tend to achieve them across the board (Noel, Levitz, & Saluri, 1995). Students who fit the at-risk profile tend to have less stability in grades, often having a combination of high and low grades in a single grading period that corresponds to a variety of factors ranging from
academic and personal issues to their efficacy in regard to course content, to time of day (or day of week), and instructional technique (Muraskin, 1997).

Both groups of students are at greatest risk of not persisting in college during their first year, with the result that, on a national level, more than half of college freshmen will not progress to become sophomores (Muraskin, 1997; Tinto, 1993). Although the leaving rate related to poor academic performance has increased in recent decades (Tinto, 1997), with at-risk students disproportionately represented (Muraskin, 1997), students who leave because they were suspended, expelled, or placed on academic probation account for only one third of leavers; the other two thirds of leavers were academically adequate (Muraskin, 1997). A study conducted at MSU-Bozeman in the fall of 2000 indicated that 41% of students' withdrawals were attributed to lack of readiness for college or college fit issues (Stryker, 2000). Retention researcher Vincent Tinto found that initial academic experiences at college and students' perception of their "academic fit" (Tinto et al, 1993) are crucial to successful adjustment to college life regarding both academic and social adjustment (Tinto, 1997). He wrote that "...the roots of successful student retention lie in better education during the first year" (Tinto et al, 1993) and advocates organization of course instruction and study through learning communities as a way to foster a perception of social and academic belongingness (Tinto, 1997) and to develop affirming connections with faculty and staff (Tinto1997, 1993). In future, understanding of academic fit may also be addressed in terms of recent research on the motivation to learn. Nakamura & Csikszentmihalyi (2002) developed satisfaction and happiness indices that improve understanding of motivation of learning in terms of "flow," the human drive to stretch
one’s abilities by striving for clear, proximal goals while receiving feedback; Schulman (2002) investigated motivation in terms of the passion to know.

Tinto’s approach focuses primarily on affective components of the social and academic atmosphere conducive to the success of college students, a place when and where students can learn. Research on learning communities and social learning also address who will learn and how students learn in terms of both affective and cognitive aspects of learning. Cognitive research on learning by authorities such as Albert Bandura (1977, 1997), Lev Vygotsky (1978 trans.), and to some extent, Jean Piaget (1954), note the attention and imitative behaviors that lead to observational learning, while psychologists studying social cognition, Bandura (1977, 1990, 1997), Bem (1972), Festinger (1957), Maddux (1992), Martin (1973), Rotter (1954), and Seligman (1967, 1990) affirm additional sources of motivation for social learning, causing Hannifin (1997) to conclude that effective teaching must be grounded in an appropriate social environment.

The importance of using learning strategies in learning is equally well documented. Najar (1999) asserts that in higher education, learning independence is essential, and that Salomon & Perkins (1989) found learning strategies provide necessary framework for independence in learning. Further, Brown, Collins, & Duguid (1989) found that the task of learning, which incorporates learning strategies, is a primary and inseparable part of learning. Regardless of importance, Chamot & O’Malley (1987), King (1994), McKeachie (1994), and Muraskin (1997) note that formal instruction in the value and use of learning strategies is largely assumed rather than authentic and is insufficient for students’ needs.
The learning strategies involved in Supplemental Instruction integrate various aspects of social, cognitive, and metacognitive learning about learning and apply it to the needs of students in challenging college-level courses. The current research in turn borrows heavily from SI, and in fact changes it as little as possible except in the areas of its limitations: SI is costly, complex, time consuming, and voluntary. Each of these detracts from the universality of its use for the institution, instructors, and students. There are also limitations on the research design, which relies on the minimal structure of written course assignments and opportunities for modeling and feedback that may occur within the lab portion of the class. The intended contribution of the current research is in terms of usability and in defining essential components of SI to integrate into structured course assignments that mimic SI in terms of eliciting student behaviors important to optimal learning. Additionally, the learning strategies involved in the research are useful to students in general, but are particularly important to at-risk students who may be unaware that useful strategies exist (Bandura, 1997; Palincsar & Brown, 1984; Vygotsky, 1978) or how to use them to promote academic success (Bandura, 1997; Brown et al, 1984; Najar, 1999; Vygotsky, 1978).

Given the considerations above and the central thesis of the research, the scope of this review of the literature will discuss learning and the role of homework in learning, then each of the following premises:

Premise 1: Learning strategies are effective in promoting learning.

Premise 2: A significant proportion of students do not use effective learning strategies.

Premise 3: The learning strategy promoted in Supplemental Instruction is effective in difficult college-level courses.
Premise 4: Students are more likely to use time-consuming study strategies that are required course assignments than the same strategies if not-required.

Premise 5: Students are less likely to procrastinate when assignments are broken down into apparently manageable blocks.

Premise 6: College instructors design course assignments in part for ease of use.

These premises will be included in the "Review of Previous Research Findings, and Opinions." The remainder of this chapter is divided into sections on reviewing criteria for selecting the literature, the context of the problem, the current understanding of the problem, the review, a review of methodologies used in other studies, a summary of the review, overall weaknesses and strengths, gaps and saturation points, and finally, avenues for further inquiry.

Criteria for Selecting the Literature

In choosing literature for review, major theorists were selected, particularly where theories overlapped and corroborated each other on themes relevant to this research. Lev Vygotsky and Albert Bandura, for instance, identified highly similar components in their respective theories of learning, all of which are applied in the strategies selected for comprehensive attention in this review. In turn, the selected strategies, SI, RT, and LTL, use similar learning processes for widely divergent groups of learners with good result, and each has been corroborated by the United States Department of Education.

Despite the paucity of research on learning strategies in comparison to teaching strategies, research is available on numerous theories currently in use. Therefore, the review of the literature includes discussion of learning theories that are related to SI in
greater or lesser ways. Included are collaborative (or cooperative) learning, instructional design, video-based supplemental instruction, heuristic theory, situated learning, information pick-up, social development theory, constructivism, discovery learning, anchored instruction, conversation theory, genetic epistemology, cognitive apprenticeship, complex learning theory and others. In general, the variation on SI proposed in the current research was supported by each of the learning theories discussed, but the specific method of implementation—structured course assignments—was not found. In contrast, most of the research involves preparatory students and high levels of supervision; some target specific populations of students. Significant attention is given to particular themes that suggest variations on methods that have been in continuous use for significant periods of time. Supplemental Instruction, the primary model, has been used at the college level for approximately three decades.

**Context of the Problem**

The current research was based on the premise that students of entry-level college courses at MSU-Bozeman have varying levels of academic preparation, including their knowledge of, and ability to use, learning strategies. The University and instructors are motivated to improve student outcomes in regards to learning in a manner that promotes the campus-wide mission of excellence. Toward that end, the research was designed to investigate how learning is affected by altering course assignments to promote use of learning strategies that have been shown to increase learning in other contexts. The wording of course assignments designed for approximately one half of the students in
general chemistry, Chemistry 131, was altered to require students to use the SGCP behaviors while working homework problems in groups of two or more.

The researcher is a student of Adult and Higher Education who has particular interest in learning strategies and has worked in Academic Affairs with Student Support Services and Retention, and with several academic departments. In these contexts, she has seen intelligent and capable students flounder academically due to their confusion regarding how and what to learn, and has seen students experience a related loss of efficacy regarding their studies. Tutoring helps many students pass classes and can build study skills for those receiving assistance, but is costly, reaches too few students, and may result in dependency and continued low efficacy (Annis, 1983; Bandura, 1997). The current research was designed to reach half of all students enrolled in a targeted course while building efficacy and skills by having students learn with peers.

An unknown factor of the research was whether students would experience a crucial benefit of SI through the less formal group work proposed: the anticipation of teaching causes learners to mentally organize information more thoroughly and to learn differently, in what Deanna Martin (SI, 1973) calls "a deeper and more connected way." The commonly experienced sentiment, "I never really learned it until I had to teach it," is an important component of social learning (Coleman, 1998; Martin, 1973). Learning theorists Albert Bandura (1997) and Lev Vygotsky (trans. 1978) include attention to modeling and assimilation of cultural tools (Vygotsky, 1978) as important aspects of social learning. All of these are included in the review of the literature as relevant components of SI with the caveat that the SGCP model of structured course assignments
of the current investigation may not induce a sufficient level of social stimulus to contribute to learning.

**Current Understanding of the Problem**

The problem stated in chapter one is that college instructors need to have improved and manageable ways to induce students to use learning strategies that are proven to be effective in promoting learning. The connotation discussed in the introduction is that instructors share responsibility with students for their learning and therefore have an interest in promoting use of effective strategies. There are several reasons why instructors might take an interest in improving student learning:

1. For reasons of professionalism, ethics, and personal gratification, instructors view increased student learning as a direct and effective measure of their own efficiency in accomplishing the goals of teaching (McKeachie, 1994).

2. Increased learning, especially as it contributes to consistency among students in terms of keeping pace with the rate and level of instruction of content, aids in classroom management, morale, and progress.

3. In a more personal way, instructors may also be invested in their students' success, and find teaching satisfaction directly related to student learning.

In addition, there are two reasons why instructors' academic departments and institutions may have a growing interest in supporting measures that increase student learning. The first reason is monetary. Shifts in national and state economics and political priorities during the 1990's have reduced levels of fiscal support provided to public institutions while general accountability has increased (Stryker, 1999). In 1999, Courtney
Stryker, Director of Retention at MSU-Bozeman, reported that since the advent of the 1990’s, institutions of higher education in general, and public institutions in particular, have been the focus of constant fiscal scrutiny from both within and without. Again, the causes are many, including demographic shifts, an economic trend in this country toward service and informational industries, national embrasure of down-sized, “lean-mean” models of efficiency, and greater competition for students (Stryker, 1999). Like the majority of the country’s public institutions, MSU-Bozeman receives less state financial support than it did in 1990, has a more diversified financial base, has increased tuition and fees, left some vacant positions unfilled, and cut personnel, course offerings, and “non-essential” expenses (Stryker, 1999; MSU-Bozeman Office of Institutional Research, 2002). In light of these changes, improvements in student success and satisfaction translate into fiscal support in terms of retention of students already enrolled, future enrollment figures, state support, and private contributions.

Similarly, minority access to higher education is of concern in terms of the university mission, accountability, and fiscal responsibility. Factors that increase student learning and help academically disadvantaged students to interact competitively with their peers are attractive to institutions and their academic departments. Prior to the 1960’s, the failure of some students to keep pace with the instructor and class was viewed as a personal failure on the part of the student attributable to individual effort and ability. However, post-World War II research and civil rights legislation of the 1960’s provided public acknowledgement that environmental factors such as students’ or parents’ levels of income, parents’ education, and students’ disabilities, posed barriers to education that were beyond the control of individual students. Changes in admission criteria and low-
cost federal loans and grants increased access and TRIO programs provided student support services to 5-7 percent of eligible disadvantaged students, but among African Americans, Hispanic, and Indian students, success rates continue to lag far behind majority population students (DHHS, 2000; Muraskin, 1997).

Supplemental Instruction, on which the research is based, is used with comparable success for all student groups (Martin, 1973, 1998). However, SI results apply only to students who voluntarily choose to engage in the program which, as the name implies, involves attendance at supplemental learning sessions. Ideally, voluntary programs allow students to choose whether they need and want additional assistance in learning course material; in a less than ideal world, however, many students experience hidden barriers to participation in voluntary programs. Three causes of non-participation are:

1. Low income and non-traditional age students with financial and family commitments may be unable to justify “extra” time for optional study programs.
2. First generation and other educationally disadvantaged students may have less understanding of the existence or value of learning strategies (Muraskin, 1997; Palincsar et al, 1993) and therefore underrate the importance of participation in supplemental programs.
3. Since SI attracts motivated students, students with low efficacy in the course may anticipate, and be intimidated by, an assumption of academic rigor.

In lieu of SI, a second program, Video-based Supplemental Instruction (VSI), has been found to be highly successful with at-risk students. VSI uses many of the same components of the original SI, but in a more structured format that substitutes attendance at live lectures with attendance at a showing of the video-taped lecture in which groups of
students are encouraged to play back lectures while stopping periodically to discuss challenging or confusing aspects. Again however, drawbacks to using VSI include institutional expense, organizational complexity, and administrative time. Given the arguments above, a second alternative to SI is warranted. The current design, which would lead to specially structured course assignments for students in historically difficult courses, has the potential to provide many of the benefits of SI with fewer drawbacks. Its design assists all course participants, including those with greatest need, without implying remedial assistance, in a low-cost, forthright manner that keeps the locus of control with the instructor.

Review of Previous Research, Findings, and Opinions

Learning

In recent decades, research on learning has consistently revealed complex interaction between affective and cognitive factors that exist within the person, and among the person, the environment, and their behavior. Learning is an integral and primary form of behavior that occurs constantly throughout life (Bandura, 1977; Piaget, 1954; Vygotsky, trans. 1978), causing individuals to serve as the principal agent of their own change (Bandura, 1977). Thus, learning is a self-regulatory behavior informed by reflexive thought that in turn, determines ensuing behavior (Bandura, 1977). Motivation for learning is equally complex. Fundamental learning through direct experience occurs due to overt consequences of incentives, no outcomes, or punishing outcomes. However, with behavior as an interactive agent that initiates as well as receives, learning cannot be limited to experiencing the effects of one's own performance responses. Instead, in his
book on social learning, Albert Bandura (1977) explains, “virtually all learning phenomena resulting from direct experience occur on a vicarious basis by observing other people’s behavior and its consequences for them” (p. 12). This capacity to learn through observation permits learners to “acquire large, integrated patterns of behavior” (p. 12) in a safe and time-efficient manner. However, observational learning is not a passive activity. Observers must attend to the behaviors of others, including verbal and social cues, and to the consequences the model experiences. Further, learners reflectively process the vicarious experiences and preserve them in symbolic form where they may solve problems and plan behavioral changes (Bandura, 1977). Bandura found that observations, then, are mediated by:

1. attentional processes, in which the observer’s selective attention is mediated by associational patterns (models with whom the learner associates) and the observer’s capacity to perceive and process information, which in turn are influenced by the observer’s perception of the potential benefits of learning;

2. retention processes, in which the observer attends to the behavior of another and subsequently organizes response patterns in verbal and imaginal memory, enhanced by mental rehearsal and physical performance, both of which increase memory and proficiency;

3. motor reproduction processes, that involve cognitive organization, initiation, monitoring, and refinement; and,

4. motivational processes, that affect both what is observed, the level of attention it receives, and what is enacted in that learners who observe valued outcomes are more likely to adopt modeled behaviors.
Learning that does not come from direct or vicarious experience occurs through cultural tools that support symbolic representation such as written and spoken language and thought (Bakhtin, 1979, 1981; Vygotsky, 1978; Wertsch, 1998). While avoiding the temptation to reduce the incredible complexity and social imbeddedness of mental activity, it is important to note that non-experiential learning is mediated by similar processes of attention, retention, motivation and reflection, and that it is a form of social learning. Vygotsky (trans. 1978) viewed intramental functioning as inherently social for two reasons. The first is that thought is socioculturally situated, or based on language, culture, experiences, and knowledge that exist in the mental sphere as a result of social interaction (Vygotsky, 1978; Wertsch, 1998). The second is that learning occurs according to the “general genetic law of cultural development” in which all facets of an individual’s cultural development appear first between people as socialpsychological interaction before appearing within the individual as intermental functioning (Vygotsky, 1981; Wertsch, 1998). Vygotsky (trans. 1978) saw close connections between inter- and intramental functioning due to the forms of dialogic speech that support all mental functioning.

The above discussion explains more about how people learn than why. Motivation for learning, as mentioned, is also complex. As Bandura (1977) explains, “If actions were determined solely by external rewards and punishments, people would behave like weathervanes, constantly shifting in different directions to conform to the momentary influences impinging on them” (p.128). Instead, behavior is often enacted “in the absence of immediate external reinforcement” (p. 129), and is an interaction of internal, or self-generated, and external forces (Bandura, 1977). Indications that learning is a constant and
self-rewarding experience are reinforced by recent research in the areas of positive psychology and the chemistry of the brain:

1. Positive psychology: in its findings that people are driven to achieve a state of flow, where happiness results from activities (learning) that challenge the actor, neither exceeding nor underutilizing the actor’s abilities while he or she is striving for clear, proximal goals and receiving feedback (Nakamura & Csikszentmihalyi, 2002). The desire for challenge is crucial here: scaffolded learning, where the level of difficulty, or potential for improvement, increases incrementally as the learner learns has the potential to engage the actor indefinitely while learners tire of single step, stagnant activities.

2. Positive psychology: in research that shows the passion to know, or to seek information, is “ubiquitous, fundamental, and begins at birth” (Schulman, 2002), and has the following four components: The learner seeks to a.) identify and classify phenomena; b.) discern temporal patterns between some of those phenomena; c.) determine causal relationships behind some of those temporal patterns; and d.) discover how to enter into the antecedent-consequent chain and become causal agents (Schulman, 2002). Schulman further states, “The function of intelligence is to gain information in each of these domains” (qtd. from The Handbook of Positive Psychology, p. 314).

3. Chemistry of the brain: evidence that the body’s chemistry rewards itself with production of pleasure-producing hormones when successful learning occurs (Greenfield, 1996).
The unique drive to learn is further supported by people’s “extraordinary capacity” to use symbols that enable them to represent events, analyze conscious experiences, communicate with others, plan, create, imagine, and predict (Bandura, 1977). Together, these features indicate that people have the ability to learn, the drive to learn, and conscious choice of what they learn.

As it turns out, the element of choice adds new layers of complexity to learning. As mentioned above in the discussion of flow, the ideal learning activity includes clear, desirable goals, challenges the learner’s abilities without exceeding or underutilizing those abilities, and provides feedback to the learner (Nakamura & Csikszentmihalyi, 2002). Learning can occur in less than ideal circumstances, but sustained learning that takes place over a period of days, weeks, months or longer is seriously compromised by a failure of any of the necessary components of goals, ability, and feedback. The sort of learning necessary for success in college courses that are the focus of the current research required sustained effort of this sort. In chemistry, successful learning of discrete portions of course information must occur, but an overall integration of concepts is also necessary in most cases. For students to choose to focus their mental energies on the tasks Bandura (1977) has outlined as attention, retention, motor reproduction, and motivation requires repetitive conscious sustained effort. Because students choose to register for course, an initial motivation to attain course goals is assumed. In order to maintain sufficient motivation to persist in learning, consider again the elements of flow: challenge, clear proximal goals, and feedback. Research reported by Jeanne Nakamura and Mihaly Csikszentmihalyi (2002) shows that motivation of effort is a complex mix of choice,
personality, perception of challenge, and efficacy. Briefly, the important points as they relate to the proposed research are as follows:

1. Motivation is higher where individuals feel they are engaging in an activity by choice rather than the perception that they have to do it;

2. When abilities are overchallenged, students feel anxious, self-conscious, and stressed;

3. Underutilization of abilities leads to feelings of boredom and apathy that challenge attentional processes necessary to learning;

4. For many students, course grades are perceived as high stakes and add to a perception that abilities are overchallenged;

5. The optimal level of challenge stretches existing skills (Vygotsky, 1978);

6. Adolescents tend to feel more motivation and happiness in low-challenge, high-skill situations than in high-challenge, high-skill situations;

7. Adults tend to prefer high-challenge, high-skill situations but have greater cultural prejudice against doing what one has to do;

8. Some personalities are more autotelic, or motivated by internal rewards, than others;

9. Some activities are more autotelic, or intrinsically rewarding, than others;

10. Efficacy, or belief in one’s ability to produce desired effects by their actions, is an essential component of motivation to act (Bandura, 1997).

Clearly, successful engagement in challenging college courses requires persistent effort to keep cognitive abilities within tolerance limits of the affective needs that mediate learning. Very few students, however, arrive at college with more than a rudimentary understanding of their own learning processes and the strategies that help regulate learning (Nager, 1999). Students may therefore approach learning in a trial and error
manner, using informal strategies that brought them success in preparatory schools.

Given the diversity of academic preparation students experience prior to entering college, diversity of success at college follows.

The Role of Homework in Promoting Learning

The literature regarding homework is surprisingly limited in scope, especially at the college level. Data compiled for the years 1983-84 reported in the National Assessment of Educational Progress (NAEP) show that approximately 65% of students in the 9-, 13-, and 16-year olds age range do homework (Anderson, 1986) and that 20% of the time students in the K-12 grades devote to academic tasks in this country is spent on homework (Cooper, 2000). However, homework, which Cooper defines as academic tasks assigned by school teachers to be done during non-school hours (1989), remains controversial in regards to advantages versus disadvantages, the efficacy of assignments, optimal amounts, and other considerations. In a review of literature on homework compiled in 2000 for the Minnesota Center for Applied Research and Educational Improvement, Harris Cooper noted that “it is surprising how little attention is paid to the topic of homework in teacher education. Most teachers in the United States report that in education courses they discussed homework in relation to specific subjects, but received little training in how to devise good assignments, how to decide how much homework to give, and how to involve parents” (pg. 1). At the college level, instructors tend to receive little or no formal training on any aspect of teaching, including the development of worthwhile assignments (McKeachie, 1994).
Reviews of the literature conducted between 1960 and 1987 vary widely in assessments of the role and results of K-12 homework. In a paper presented at the Annual Meeting of the American Educational Research Association (1988), Daniel Levine argued that the NAEP's publication, "The Reading Report Card," portrays a misleadingly positive relationship between homework and achievement. Instead, he found that community factors such as percent of minority students in schools and levels of parental education affected the relationship between homework and reading outcomes. Nine studies that investigated academic performance as a function of time spent on homework found that the performance of elementary students did not improve with time spent on homework, but that junior high performance increased somewhat while high school achievement showed a positive relationship with time spent on homework (Cooper, 2000). Interestingly, the benefits of time spent on homework indicated a saturation limit after which they decreased. In a study of teacher education students, Tuckman (1992) found that short assignments produced a greater quantity of work than long assignments. An NAEP report for the National Center for Educational Statistics that compared reading assessments for the years 1992 to 2000 showed average reading scores for fourth graders to be highest for students who reported doing one hour of homework per day (222), slightly lower for those reporting one half hour per day (219), but lower yet for those reporting more than one hour (212). While those spending more than one hour may reflect difficulty in completing assignments, corroborating data indicates that students become bored when homework is over-assigned, lose interest in academic tasks, experience physical and emotional fatigue, and that students from lower socio-economic homes have less assistance completing challenging assignments (Cooper, 2000).
NAEP data showed that fourth graders who report that they do not have homework achieved reading scores of 212, identical to those who do more than one hour, while the two percent of students who were assigned homework but do not do it had a mean score of 172.

The questions of whether homework improves student achievement and the characteristics of assignments that promote learning have been the subject of many studies in K-12 settings. Some examples of issues discussed are Foyle and Bailey (1986) who wrote a series of articles stating that the purpose of daily homework should be to prepare students for the next lesson or to practice concepts and skills learned in the previous lesson, and that homework is more productive when it is clear, meaningful, varied, and regularly assigned. Cooper, Lindsay, and Greathouse (1998) found that overemphasizing grades and performance on homework may lead to cheating if students worry about school, perceive the school as focused on grades and ability, expect to be rewarded for doing well, attribute failure in school to outside circumstances, and do not know how to use or avoid using active learning strategies. Anderson’s analysis of NAEP results (1986) led to recommendations that assignments be made with the understanding that students need parental support to complete assignments, teachers and parents should set clear goals for homework assignments, and homework policies should be consistent with other school goals. In a recent interview on National Public Radio (March, 2003), Joyce Epstein of the Center on Families, Communities, Schools at Johns Hopkins University said that a good homework policy goes beyond the details of how homework is administered and focuses on how assignments are designed (See Epstein, National Public Radio; 2003). According to Epstein, over-dependence on textbook exercises as
assignments frustrate students over a period of time; as an alternative, she recommends that teachers plan a mix of assignments to meet specific learning goals.

As a result of his comprehensive review of more than 120 empirical studies, Cooper (2000) devised a list of positive and negative effects of homework, and a model of factors influencing the effects of homework (see Table 1). Many of these apply to higher education as well. At the college level, some of these factors are irrelevant. However, others are both relevant and the focus of this study. In particular, the positive outcomes of retention, understanding, critical thinking, concept formation, information processing, independent problem solving, and better study habits and skills are of interest. On the negative side, the contention that homework may cause increased differences between high and low achievers is a concern that is also addressed in the current research.

Table 1: Cooper’s Suggested Effects of Homework

<table>
<thead>
<tr>
<th>Positive Effects</th>
<th>Negative Effects</th>
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<tbody>
<tr>
<td>Better retention of factual knowledge; Increased understanding; Better critical thinking, concept formation, &amp; information processing; Curriculum enrichment; Learning encouraged during leisure time; Improved attitude toward school; Better study habits and skills; Greater self-direction and self-discipline; Better time organization; More inquisitiveness; More independent problem solving; Greater parental involvement in school.</td>
<td>Satiation: loss of interest in academic material; Physical &amp; emotional fatigue; Denial of access to leisure time &amp; community activities; Parental interference; Pressure to compete &amp; perform well; Confusion of instructional techniques; Copying from other students; Help beyond tutoring; Increased differences between high &amp; low achievers.</td>
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In addition, Cooper categorized factors that influenced the effects of homework as:

1. exogenous factors of ability, motivation, and study habits, and subject matter & grade level;
2. assignment characteristics of amount, purpose, and skill area utilized, degree of individualization or choice, completion deadlines, and social context;
3. initial classroom factors such as availability of materials and facilitators, approaches, links to the curriculum and other rationales;
4. home-community factors of competition for students' time, environmental issues of space, light, and quiet, and materials, and involvement with other students or other individuals; and,
5. classroom follow-up such as written or oral feedback, grading, or incentives, testing of related content, and use in classroom discussion.

While each of these play a role, Cooper (2000) notes that the most telling feature of the effectiveness of homework in preparatory school is the grade level: of 50 studies that correlated achievement with time spent on homework, 43 showed positive results for high school students with a mean of $r = +.25$. Given the generally good outcome, Cooper recommends using homework to practice skills already taught in the classroom and as a simple introduction to new material.

At the college level, the purpose of homework often goes far beyond Cooper's recommendation for preparatory schools. The rate of learning expected in college courses creates strong dependency on assignments to extend the time available for assimilation of materials. Since colleges also require students to learn a wide array of subject matter, Sandra Zerger (1994) notes that many students will find themselves challenged in one
area or another. For example, students who excel in science, in which truth is independent of time and context, may have trouble with the humanities where metaphor, uncertainty, and insight are valued and truth is highly contextual. VerBeek and Louters (1991) found that chemistry involves a complex interaction of multiple skills that requires competency in mathematics, problem solving, conceptualization, theories, and chemical language. Acquisition of these skills can be integrated in course content or may be implied to students through course assignments. The role of homework then affects not only what is learned and how it is learned, but also defines instructor expectations.

Learning Strategies are Effective in Promoting Learning

When people undertake complex and important enterprises, they often take steps or form a strategic plan to enhance the likelihood of achieving success. From the instructor's perspective, formal education is a strategically designed enterprise with layers of planning that reflect a great deal of forethought and experience. Plans include learning materials and scaffolded experiences designed to afford students the tools they need to assimilate learning objectives, with alternative courses and classes to accommodate students of varying ability or readiness. In theory, students should be well-served by the educational system. In reality, though, education is much messier. Individual differences in matters of cognition, affect, communication, efficacy, interest, motivation, ability, and imagination—to name a few—affect classroom interactions in ways that favor learning of some students over others (Boyer, 1987; deMarrais & LeCompte, 1999). Students who experience greater amounts of success in preparatory schools make up the majority of college entrants where they often find the rules have changed toward less structure and
more reliance on self-direction. Where the educational strategy of instructors was previously sufficient to support these students' efforts to learn, they now find that they must rely on their own strategies. The difficulty here is that many students are not consciously aware of using learning strategies and, despite academic anxiety, may not recognize the need to develop a strategy in time to assure success in college.

In their research on reciprocal teaching, Palincsar and Brown found that middle-school students with persistent problems in reading comprehension lacked understanding and knowledge of learning strategies. Interestingly, their ability to decode written texts was sufficient, but they lacked understanding of how to organize information into patterns that conveyed value to bits of information. For example, in the sentence (simplified example), “The yellow dog ran down the hill,” “yellow” serves to describe the dog while the phrase, “ran down the hill” describes the action performed by the dog. The children Palincsar studied did not initially organize reading material in ways that informed their comprehension—when asked the main point of the sentence, they were as likely to say that the dog was yellow as that it ran down the hill. Further, the students did not understand the instruction they received regarding reading comprehension and continued to lag far behind their peers, testing at rates of 15-30 percent comprehension.

Palincsar and Brown devised a method to teach these students in which the readers met in a social learning group where each student took turns using a particular learning strategy and serving as the teacher for the others. The student-teacher's responsibility was to lead discussions about the meaning of reading passages, however in the beginning, they were unable to do so. The group's adult teacher assisted the student-teacher as needed, sometimes forming the entire question that the student-teacher would then repeat for the
group. Despite their lowly beginnings, after twenty-five days of instruction (one hour per day), 80 percent of the students consistently tested at 75-85 percent on numerous measures of comprehension including ability to draw inferences, ability to summarize, and application of knowledge to a novel situation, and maintained their progress six months to a year from the end of reciprocal teaching sessions (Brown & Palincsar, 1982; Palincsar & Brown, 1984, 1989; Palincsar et al, 1993; Wertsch, 1998). Subsequently, reciprocal teaching has been used with comparable success with students of different ages and abilities. Its ability to assist poor-performance students who were highly resistant to other methods of teaching led Bruer (1993) to dub it the “educational equivalent of polio vaccine” (qtd. in Wertsch, p. 2, 1998).

Reciprocal teaching is discussed here for two reasons. The first is that Brown used existing research on reasoning and reading to develop the protocol for reciprocal teaching, a protocol that has students work in groups of 6-8, take turns leading the group in the role of teacher, and perform summarizing, clarifying, questioning, and predicting activities, while the teacher serves as model for the desired behaviors and assistant to each student-teacher in turn. In describing reciprocal teaching, Wertsch (1998) hypothesizes that the remediation of poor readers provides them “with new items in their ‘cultural tool kit’” (p. 127) that allow them to appropriate strategies and that are explicit about appropriate use of the strategies. Wertsch notes the concrete structure provided to students and the “significant and serious epistemic roles” (Nystrand, 1997, qtd. in Wertsch, 1998) provided to students through the exercise. Together, these factors address many of issues raised in above sections, such as challenging students in a manner that neither overtaxes nor underutilizes their abilities; providing clear, proximal goals and
feedback; attending to students’ attentional, retentional, motivational, and reproduction processes; and raising students’ efficacy by increasing their success in a socially rewarding environment.

The second reason reciprocal teaching is discussed in some detail here is that it is strikingly similar to two other highly successful programs designed to involve students in using learning strategies, Supplemental Instruction (SI), and Learning to Learn (LTL). In two of the three, RT and SI, students work in small groups, using the strategies of summarizing, clarifying, questioning, and predicting activities while taking turns serving in a leadership role that challenges their understanding of the material and the strategies in use. The groups are collegial in that they share common goals and support each other’s learning endeavor, but challenge learners by placing them in the role of leader. The main difference between RT and SI is that RT is remedial while SI carries no stigma due to its association with historically difficult college courses and voluntary participation. A third system, Learning to Learn (LTL), was developed in the 1960’s by Marcia Heiman at the University of Wisconsin (Heiman & Slomianko, 1987) and was a precursor of SI of the 1970’s and RT of the 1980’s. All three are still in use, are endorsed by the U.S. Department of Education as Exemplary Educational Programs, and are considered successful.

As examples of “success,” in one study, LTL students earned a 2.9 GPA and completed more credits than a control group of comparable students who earned a 2.2 GPA while follow-up data revealed persistence rates three semesters after completion of the LTL program to be 70% for LTL and 40% for non LTL students (Heiman, 1987). In SI, research confirms that its use improves student performance, increases continued
enrollment, and improves learning skills including thinking and reasoning, responsibility, and reflection (SI Training Manual, 1998).

LTL teaches students to actively organize course content through analysis (or input), synthesis (organization), and evaluation (output), or, more specifically by:

1. identifying the components of complex concepts (summarize, clarify)
2. breaking down complex tasks into small units (study skill)
3. asking themselves questions during reading and forming hypotheses (predicting), then read or listen for confirmation (feedback)
4. devising informal feedback devices for themselves (predict, generate questions)
5. focusing on instructional objectives and directing their own study to meet course objectives (clarify, metacognition)

While LTL did not organize students into social learning groups, it did advocate thinking independently and systematically and to be goal-directed in analyzing course materials. In a well-received book published last year, Richard Light of Harvard (2001) identified similar thinking which he likened to thinking like a professor as a key strategy in successful studying. Additionally, Light cited four concerns that lead to academic distress: poor time management, failure to navigate the transition of high school- to college-level organizational requirements, selection of large lecture courses and consequent failure to interact and connect with faculty and staff, and studying alone. Light’s concerns also highlight the need for students to adopt study strategies and to study collaboratively.

Collaborative learning will be discussed in detail below, but is mentioned here for its role in learning strategies. Considerable research supports the efficacy of group
learning, with much of it (Bandura, 1997; Bruner, 1989; Vygotsky, trans. 1978) emphasizing the building of knowledge through interactive constructivist dialogue made more meaningful and approachable by social interaction. A necessary component of communication involves verbal organization of ideas and, since one cannot articulate that which they do not understand (Vygotsky, trans. 1978), learners who work collaboratively work more diligently to organize their thinking, and organize in what Deanna Martin (1973) calls "a deeper and more connected way." Organization of ideas is a major goal of learning strategies—activities such as summarizing, clarifying, questioning, and predicting are all essentially ways to organize, process, comprehend, and retain information. A further benefit of social learning in relation to learning strategies is that learners assimilate knowledge from models—both discrete bits of information and, where applicable, the methods by which they are attained. Students who are proficient with learning strategies are likely to be more articulate and knowledgeable about the topic under study than those whose thinking is not informed by strategies, so will serve as attractive models in social learning groups where other learners can appropriate their use of strategies.

Effective Learning Strategies

A significant proportion of students do not use effective learning strategies. Cook and Mayer (1983) have identified three non-exclusive categories of strategies that are commonly referred to as "learning strategies." The first is task-limited strategies in which specific goals drive learners to focus their efforts in a particular way to learn specific information. For example, in mathematics the learner might practice skills by working
problems, seek feedback regarding the correctness of efforts, use mnemonic devices to remember the order of operations, try alternative methods such as guessing or re-reading sections of the book, and other means of accomplishing the task at hand. The second is goal-limited strategies which are used in more general tasks such as problem-solving, comprehending, and remembering. The third type are general strategies by which students monitor themselves and their learning and include skills such as time management, test-preparation, and metacognitive oversight of need for more task-limited or goal-limited effort. Nager (1999) writes that successful students integrate the three types of learning strategies and are able to appropriately transfer skills to new areas as needed.

Although learning strategies are proven to be effective, many students are not explicitly aware that strategies exist or that it is advisable to use a strategic approach to learning (Burd, 1996; Nager, 1999; Palincsar & Brown, 1984). One study estimates that one third of all entering freshmen in this country lack the skills and academic preparation necessary to succeed (Burd, 1996). Hays (1995) found that learning-disabled students tend to have deficiencies in academic skills, and Muraskin (1997) reports similar difficulties among TRIO-eligible at-risk students. O’Malley and Chamot (1990) found that learning strategies may not translate well from other languages to English, and that students for whom English is a second language (ESL) often require explicit instruction to assist comprehension. Anecdotal evidence from MSU-Bozeman indicates that many students do not discover strategies or attend to their use until they experience significant academic need. As an example, the primarily-freshman students referred to the Dean’s office and the TRIO Student Support Service program through the University’s early
warning system (the D & F list) issued in mid-semester and students who are on academic probation are more receptive to information regarding study strategies and study skill workshops than students who are not experiencing need. However, most students with GPA’s in the range of 2.0 to 3.0 are not likely to seek out information despite need (Noel, 1993). Additionally, students at various stages of education who do attend workshops or study related courses often express surprise that there is a science to learning.

As an example of the problems students encounter, consider the autonomy expected of college students in regards to reading texts. When teachers in preparatory schools assign readings in a text, they typically also cover required material in class and provide structure and discussion that aids students in decoding, comprehension, and identification of material that should be remembered. In college, the epistemic role of the reader changes. Students tend to be assigned more reading than can be discussed in lecture and which may be supplemental to other course materials, yet figures heavily on exams and general course learning for which students are responsible. While some students are academically prepared to structure their own learning, others become overwhelmed and confused. McKeachie (1994), for instance, identified seven reasons why students might fail essay exam questions. At least five of these point to deficits in learning:

1. The student does not understand the question.
2. The student has not learned the material.
3. The student lacks specific cues for retrieval.
4. The student lacks an appropriate strategy for retrieving the material.
5. The student lacks words needed for an answer.
6. The student lacks a conception of the required solution; for example, when asked to “explain,” she lacks an adequate conception of what is involved in an adequate explanation.

7. The student cannot hold required material in active memory while writing the answer. McKeachie explained that even memory is dependent on cognitive processing in that students must effectively and actively organize materials to be learned into categories that aid recall and understanding. Students who passively read texts or attend lectures may find that while they possess memory of the material, they have not processed it in a meaningful way; test questions may therefore tax their working memory beyond the constraints of the time available or ability to respond in the test situation (McKeachie, 1994).

Palincsar and Brown (1984) note that aside from basic decoding skills, students’ ability to learn from texts depends on three factors:

1. considerate texts, or texts that are well written in regards to clarity, coherence and style of presentation;

2. compatibility of the reader’s knowledge with textual content; and,

3. the active strategies readers use to enhance understanding and retention, and to avoid failures in comprehension.

Brown (1980) found that skilled readers read automatically, constructing information as they go, until their attention notes a “triggering event” such as a failure in comprehension. That failure alerts the reader to a need to allow extra time and effort to process the difficult material. Another triggering event would be when the reader’s expectation (or predicting strategy) is not confirmed, or when text contains so much
unfamiliar information that slow, active, planful, and strategic processing is necessary for comprehension. Reading for retention and comprehension requires far more use of active learning strategy than recreational reading, in that readers employ a split mental focus in which they are reading and performing organizing, remembering, understanding, and critical thinking tasks simultaneously (Brown, 1980; Palincsar & Brown, 1984). College freshmen have differing levels of ability to perform these tasks and also have different levels of understanding of academic expectations and the degree to which they should devote time and effort in directing their own learning. For some students, the event triggered by challenging portions of text is an onslaught of anxiety followed by procrastination behaviors or, conversely, procrastination behaviors followed by increased anxiety (Bandura, 1997). McKeachie suggests giving students an explicit understanding of learning theory so that they know why strategies work. “Cognitive psychology reminds us that as students learn a subject matter they also learn something about the skills involved in learning that subject matter. I would suggest that we help students become more effective at learning if we are explicit about the reasons we engage them in discussion, require a term paper, or carry out other activities” (McKeachie, 1994, p. 286). Implicit in his reasoning is McKeachie’s belief that students who desire to learn use strategies that they expect to find effective. In addition, students who have strategies that they believe to be effective are more likely to use them and to have higher efficacy regarding learning (Bandura, 1997). Dell's ethnographic study of American Indian transfer students (2000) found that personal determination affected persistence and the acquisition of effective study and learning strategies which in turn enhanced positive attitudes and persistence. In all cases, greater efficacy regarding learning leads to greater
persistence and less procrastination in studying, leading again to greater success and
continued rise in efficacy (Bandura, 1997; Seligman, 1990). However, many students do
not consistently use learning strategies for one of the following reasons:
1. they are not aware that learning strategies exist;
2. they believe learning strategies require more time and effort than they are worth, or
   that they are only for use on "special" occasions; or,
3. they feel they should do assignments as assigned, rather than "make up" added work.
McKeachie suggests explicit instruction regarding strategies to reduce such
misconceptions.

Many of the strategies listed above rely on metacognitive oversight and include the
expectation that students think about thinking. Garner and Alexander (1989) found that
metacognitive strategy is necessary to monitor one’s own learning and the use of strategy
in that learning. They termed this “knowing about knowing,” which involved an interplay
of cognitive and metacognitive strategies, where cognition included encoding, memory
and comprehension of information (learning activities) and metacognition included
planning, monitoring and evaluating learning activities (Garner & Alexander, 1989).
Bruner (1996) used the term “agency,” meaning to take control of one’s own mental
activity, as the first of four steps in how learning occurs. Metacognition comes more
naturally to some students than to others. In their work with at-risk students, Harris and
Pressley (1991) note that students must be explicitly informed that an objective of using
learning strategies is to become a self-regulated learner. Flavell (1985) defines self-
regulated learning as a systematic process initiated by the learner in which thinking and
behaviors such as self-monitoring, self-instruction, and self-reinforcement are directed
toward achieving learning goals. Flavell found that self-regulated learning is dependent on metacognitive knowledge but that both involve knowledge of the task (what is to be learned, and when and how), and knowledge of one’s own interests, capabilities, and attitudes. Learners then follow a learning sequence in which they analyze what needs to be learned in relation to what they know and their own characteristics as a learner, make a plan to accomplish the learning goal, implement the plan, monitor progress, and revise the plan as needed (Flavell, 1985). Explicit knowledge of the existence, importance, and use of strategies for learning supports the sort of understandings and construction of knowledge necessary at the college level (Muraskin, 1997; Najar, 1999; Salomon & Perkins, 1989).

Numerous findings indicate that students who are at-risk for academic failure have had fewer opportunities to learn to apply basic thinking skills to learning tasks (Muraskin, 1997; Palincsar & Brown, 1984). Disadvantaged homes are less likely to provide exposure to interactive learning situations (Heath, 1981), and subsequent educational remedies compound problems by providing more attention to decoding skills than to comprehension-fostering activities (Collins, 1980; deMarrais & LeCompte, 1999; Vygotsky, 1978). Further, an interesting ethnographic study conducted by Kathleen Wilcox (1982) suggests that bias in preparatory education affects which students receive explicit teaching in regards to coping with the demands of higher education and which do not. Wilcox found that students whose parents held upper middle class positions were taught to be internally motivated, autonomous, and self-actualizing while students whose parents held lower-middle class positions were taught to follow external supervision (Wilcox, 1982). Aside from the obvious ethical implications, these findings highlight the
need for colleges to explicitly inform all students about learning strategies to provide those who have been taught only to follow directions with information necessary to success in the autonomous atmosphere of a college campus.

**Supplemental Instruction**

The learning strategies promoted in Supplemental Instruction are effective in difficult college-level courses. SI uses a peer-led group format to provide supplementary opportunities for students to review course lecture materials and summarize, clarify, or discuss questions they may have regarding their learning (Martin, 1987, 2000). Since students who participate take turns serving in the role of teacher, they also use predicting behaviors, and are challenged to organize learning and put greater effort into comprehending (Martin, 1973, 2000). Each component of SI is supported in the literature and the process of SI as a learning unit is also supported. Several components of SI have already been discussed; this section adds to that discussion and reviews SI findings.

Students who enroll in historically difficult college-level courses are likely to run into the sort of reading comprehension difficulties described in the preceding section, and have similar concerns with lecture topics and other course materials. With very minor alteration of wording, the same components that Palincsar and Brown (1984) identified as important to comprehension of texts can be applied to these areas:

1. considerate content that is well worded in regards to clarity, coherence, and style of presentation;

2. compatibility of the reader's knowledge of content; and,
3. use of active strategies by which learners enhance understanding and retention, and avoid failures in comprehension.

The first of these, clarity and coherence, appears to be strictly the domain of the course instructor who chooses texts and designs lectures, but is also a measure of affective and cognitive flexibility of students (Gagne, 1985). Those who have experience with and tolerance for variety in vocabulary and speech genres, and a sense of logical organization for narrative (Bruner, 1990; Wertsch, 1998), will experience greater ease in making sense of challenging materials. As mentioned above, also useful are learner strategies that organize various sources of knowledge such as notes, texts, and questioning (Heiman, 1987; Palincsar & Brown, 1984; Martin et al, 1987; Muraskin, 1997; Pressley & Levin, 1987). The format of SI encourages students to use a variety of strategies to address the learning challenges that they meet, and the collaborative format provides a greater pool of expertise to tap in interpreting and organizing understandings. As with Reciprocal Teaching, students use summarizing, clarifying, question generating, and predicting strategies to articulate concepts, and think as their instructor would of the interconnections that link various course components.

Collaborative learning is a component of SI that is strongly supported in the literature (Arends, 1994; Bandura, 1997; Bruner, 1996; Collins Brown & Newman, 1989; Heiman, 1987; Lave, 1988; Martin et al, 1987; Palincsar & Brown, 1984; Vygotsky, trans. 1978). Bandura (1977) wrote that all learning is socially embedded and that efficacy can be enhanced by positive feedback and through reduced inhibitions realized by witnessing the success of models. Lave (1988) found social interaction to be critical to situated learning, which generally occurs outside of classrooms as a function of an
activity within a natural context and culture; Lave’s successors used situated learning to provide a more concrete base for abstract learning by applying problem solving skills and developing cognitive tools within a classroom situation made normal by social interaction (Brown, Collins & Duguid, 1989). In 1934, Vygotsky (trans. 1978) described a zone of cognitive potential (zone of proximal development, ZPD) in which the base of what learners already know is represented by what they could work out independently while that which they could assimilate while working socially with an advanced peer or teacher represented areas of active learning. In early work, Bruner (1961) theorized a constructivist style of learning (discovery learning) through Socratic dialogue between instructor and student, and in later work (1986, 1990) expanded the role of social and cultural interaction in learning. Collins, Brown and Newman (1989) devised a method of “cognitive apprenticeship” in which an expert models cognitive processes that then inform students’ metacognitive thought processes and provides coaching in areas of articulation, reflection, and exploration. Arends (1994) developed academic competitions between student teams to foster cooperative and collaborative learning.

Additional research exists to support the efficacy of learning by teaching others. In Whitman’s report (1988) on peer teaching entitled, To Teach is to Learn Twice, the term peer teaching refers to a more advanced peer, or near peer, assisting a less advanced student while co-peers are more nearly matched in ability. In both cases, learning is enhanced because responsibility for learning rests with the learner rather than the teacher (Whitman, 1988). Annis (1983) found that peer teachers learned better than peer learners, and that it is better to be a tutor than to be tutored in terms of understanding and retaining learned material. McKeachie (1994) lists the most effective teaching strategy as “students
teaching other students” (p.144) and suggests three classroom conditions to enhance the success of teacher-initiated group work:

1. be explicit about the benefits of working together;
2. make sure students understand their task; and,
3. oversee or “listen in” on group work to be sure students are not confused.

Gruber and Weitman (1962) found that small, student-led groups exhibit more question-asking behaviors, or curiosity and interest, than students in teacher-led groups, while Dueck (1993) found that students learn more in groups of three than two. Dueck was able to identify a number of strategy-based learning behaviors that occur in peer groups, including reviewing, organizing, consolidating existing knowledge and material, learning the structure of knowledge, adding meaning, noting deficits in understanding and asking and answering questions, reformulating understandings into new conceptual frameworks, and improving communication skills (Dueck, 1993; Whitman, 1988). Peer learning is also effective in creating tolerance for uncertainty and conflict that in turn leads to persistence in learning and a belief in one’s own ability to create knowledge (Goldgrab, 1992). Goldgrab (1992) also notes an increase in persistence among adult learners related to bonds formed among learners. The wide variety of group learning situations that have been found to enhance learning attest to its efficacy and a measure of flexibility in using group formats to assist in student learning and in modeling and assimilation of successful learning strategies.

Group work is not always an advantageous way to learn, nor are all students suited to work within a group. Individual effort affords more opportunity for reflective, metacognitive oversight, flexibility in personal preference, pride in accomplishment,
development of a personal work ethic and ability to persevere, and attention to detail. However, working in groups has the potential to provide the following benefits:

1. Can diminish frustration and increase tolerance levels in regards to quantity of materials to be covered and the difficulty of materials (Johnson, Johnson, & Smith, 1991; Martin, 2000);
2. Can be a source of feedback for learners;
3. Assists in motivating students to study productively and to schedule study sessions (Martin, 2000);
4. Provides models or advanced peers to help guide less-accomplished students’ learning (Bandura, 1997; Vygotsky, trans. 1978);
5. Provides models for alternative ways of note-taking, study strategies, methods of problem-solving, presenting data, and other academic tasks; and,
6. Provides an audience as motivation to help students learn through teaching others.

Supplemental Instruction uses a mix of peer leaders, who are trained and paid professionals, and co-peers, who participate in return for organized study sessions that enjoy many of the benefits listed above. SI is reported to be financially cost-effective based on actual costs versus institutional savings. Expenses include the 3½ day training for the SI supervisor at UMKC, the portion of salary necessary for supervision of SI leaders, SI leaders’ salaries and textbooks, photocopy costs, and publicity. Actual costs vary with the number of courses in which SI was offered, the number of groups formed for the courses, how SI leaders are paid (workstudy, tuition stipend, cash) and other factors, however, at UMKC, a cost of $47 per student per course was average during the 1980’s (Martin, 1998). In return, SI can be substituted for costly one-on-one tutoring
programs, and can provide revenue increase due to increased rates of retention and re-enrollment. Although SI leaders require training (12 hours of paid training prior to the start of the semester and scheduled meetings during the semester), they are trained as facilitators who provide structure to group study sessions, not as teachers who lecture or introduce new material. Instead, as successful students in the course, leaders model thinking processes and thinking about the course content as well as integrated use of study skills such as note-taking, organization, and test preparation.

SI is used in historically difficult college courses with “historically difficult” defined by a single factor, a course dropout/D&F rate of 30% or higher. SI data taken over the years 1980-1997, during which 422 courses using SI were monitored, showed impressive overall results (see Table 2). Since SI is voluntary and attracts already motivated students, overall course gains can only be estimated, but as it targets courses known to have previous dropout/fail rates of at least 30%, Table 2 figures represent a minimum gain of 3.17% with corresponding increase in course grades.

<table>
<thead>
<tr>
<th>Table 2: Supplemental Instruction Data, 1980-1997*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Students = 42,970</td>
</tr>
<tr>
<td>= 100%</td>
</tr>
<tr>
<td>% of A &amp; B grades = 45.9%</td>
</tr>
<tr>
<td>% of D, F, &amp; W grades = 26.8%</td>
</tr>
</tbody>
</table>

*Numbers calculated from figures given in Martin, 1998.
Martin (1998) writes that where SI has been temporarily suspended due to an administrative problem such as lack of peer leaders, attrition rates returned to pre-SI levels. Overall evidence shows that Supplemental Instruction and the learning strategies used in SI are effective in promoting success in historically-difficult college-level courses.

**Required Course Assignments**

Students are more likely to use time-consuming study strategies that are required course assignments than the same strategies if not required. Lest this premise appear too self-evident, its defense will be discussed in relation to time management, procrastination, and motivation. Richard Light (2001) listed poor time management as the first difficulty students encounter in college academics. Oddly, an excess of time can be as unproductive as too little time for students who have meager experience managing their own learning. Tinto (1993) notes that the first six weeks of school are particularly challenging for entering students who are unsure of their college fit in terms of academic and social adjustment. Early weeks are also the least structured time for students in terms of course assignments, tests, and labs, allowing many students to underestimate study requirements and get into poor social and academic habits. Traditional-age freshmen are used to structure in the form of teacher expectations, assignments, and frequent feedback, and often find the comparative lack of oversight at college confusing and disconcerting (Muraskin, 1997). In addition, the reduced structure masks the true academic challenge of college during early weeks so that when midterm exams and papers are due, freshmen tend to be particularly unprepared.
Assignments that are high-risk but largely unstructured, that are perceived to take large amounts of time, and that have relatively distant due dates evoke procrastination strategies in up to 70% of students (Bandura, 1997; McKeachie, 1994). Consequently, students procrastinate, or delay in the performance of tasks, most often in reading, studying for tests, and writing papers. Students who are adept at learning strategies break large tasks into smaller, more manageable units that do not evoke feelings of helplessness or the desire to procrastinate (Bandura, 1997). Even these students may procrastinate, however. McKeachie points out that many students know more about strategic learning than their performance indicates, and that it takes what Paris and colleagues (1983) termed a combination of skill and will to put strategies into use. Will is enhanced by competence and the perception of competence, or efficacy, which in turn is enhanced by performance feedback (Bandura, 1997; McKeachie, 1994). Maddux (2002) explains terms in that skill is what one can do, while self-efficacy is what one believes one can do with skills under changing, challenging situations. Alternatively, self-efficacy is a belief that one can perform the behavior that produces an expected outcome under particular conditions (Bandura, 1997; Maddux, 2002). Self-efficacy develops over time through experience (performance, vicarious, or imaginal experience) and can be affected by social interaction such as verbal persuasion, and by physiological and emotional states (Bandura, 1997; Maddux, 2002). An already stated but highly important tenet is Bandura's contention (1997) that the will to act is inherently dependent on the individual's belief that the action will produce a desired effect. Combinations of skill and will lend students sufficient confidence in positive outcomes to motivate them to expend effort on performing behaviors such as going to class and studying. Even students who
experience the greatest amount of flow in learning tend to prioritize their studies, performing required tasks in a timely manner and continuing with reading and optional tasks as time permits.

**Procrastination**

Students are less likely to procrastinate when assignments are broken down into apparently manageable blocks. Studies of procrastination indicate that it is a subconscious self-defense mechanism for self-esteem that works by inhibiting people from performing actions that they do not believe will result in a desired outcome (Bandura, 1997). Maddux (2002) defines self-esteem as how one feels about oneself and how one feels about those beliefs. In studies of learned helplessness (1967) and learned optimism (1990); Martin Seligman found self-esteem to be a crucial element of persistence. As such, procrastination’s role in preserving self-esteem could be considered a useful strategy in permitting overall continuation of the ability to act. In academic circumstances where procrastination is found to negatively impact grades, procrastination on one academic task can easily snowball into failure to put forth sufficient effort for an entire course or semester. However, if procrastination serves to preserve self-esteem, it may still accomplish its goal in that self-esteem is not seriously impinged by the thought, “Yes, I failed, but it’s not as if I tried!”

Petersen and Steen (2002) relate certain human responses, including procrastination, as a form of passivity or “holding still” response similar to observed responses in learned helplessness situations, but of a more complex and transient nature. As such, and because of the tendency explored in the section above for students to procrastinate most on
complex, high-risk low-structure tasks with little proximal feedback, instructors can do much to restructure assignments in ways that reduce procrastination tendencies. Maddux (2002) emphasizes the importance of providing early opportunity for student success and performance experience because “seeing is believing.” Additionally, Maddux notes that success is most likely when both goals and strategies are specific, and the perception of risk reduced.

Ease of Use

College instructors design course assignments in part for ease of use. As professional educators, college instructors are masters of both time management and successful problem solving. As such, they consider all aspects of course design, including efficient and effective use of their time and the time of their teaching assistants (McKeachie, 1994). “Ease of use” in regards to course assignments is used here in reference to design, implementation and assessment—all factors that instructors consider in planning the semester’s activities.

Review of Methodology Used in Previous Research

Reciprocal Teaching

In a pilot study, Brown & Palincsar (1982) developed a procedure they called reciprocal teaching in which researchers used the SGCP strategies with good result in fostering comprehension among poor readers. In a follow-up study conducted by the researchers in 1984, Palincsar and Brown chose 37 seventh-grade students to partake in a "guided learning interaction" study. Thirteen of the students did not have reading
difficulties, while 24 met two criteria of reading comprehension difficulties in that their reading comprehension was at least two years below grade level, and their baseline performance on the experimental task was below 40% correct. Additionally, they were diagnosed by teachers as being adequate decoders but poor comprehenders. Initially, six of the 24 poor comprehenders were assigned to a reciprocal teaching condition (group one) and six to an untreated control group (group 3). Six months later, six received an alternative intervention, empirically supported, (group 2) and the final six received daily practice with the assessment packages but no intervention (group 4). The 13 students of average reading ability were used to establish baseline data for initial and maintenance tests.

In group one, participants received reciprocal teaching intervention in which participants interacted in small groups in which teachers modeled, and students emulated, comprehension-fostering activities of summarizing, clarifying, generating questions, and predicting. In this group, students were assigned to teach reading segments and were given increasing independence in this role as their abilities increased. A second group of six received information-locating intervention, in which students were given practice in test taking while the teacher initially modeled locating answers to comprehension questions. In both cases, the same texts and assessments were used, teachers provided modeling, and students were given daily feedback on their progress. The reading passages used for all four groups were chosen to conform to the Fry Readability Formula for seventh graders and test questions were categorized as text explicit, text implicit or script implicit by independent raters. Additionally, in both intervention groups, students
were told explicitly and often that the strategies they were using would help with understanding material and that they should use similar strategies when reading silently.

All dialogues of the RT groups were recorded, transcribed, and scored by independent raters, showing a progression from mimicking, unclear questions and detailed summaries to main idea questions and higher quality summary statements of 54% to 70% and 52% to 85% respectively. Additionally, students' choice of words progressed from expressions taken verbatim from the text to paraphrasing and integration of ideas across a passage. The teachers' assistance showed a similar progression, providing more sophisticated intervention and encouraging ever-more independence on the part of students. To provide objective assessment, independent raters randomly chosen portions of transcripts and ranked them as beginning, middle, or final phase, with 83% agreement on beginning and final phase segments and 67% agreement on middle phase. A 3X4 mixed analysis of variance was conducted on comprehension tests with groups as a between-subjects variable and phase as a within-subjects variable and interaction between group and phase was tested.

Results showed reciprocal teaching led to dramatic improvement in student scores while practice in test taking and the alternative intervention did not show reliable improvement. Four of the six RT students (group one) reached a stable level of 80% correct from a baseline of below 40% in 12 days of ½ hour interventions. A fifth student stabilized at 70% correct in 12 days. The remaining RT student went from a baseline of 10% to a steady level of 50% correct, again in 12 days, but did not improve beyond that level. The 13 average students achieved 75% correct without intervention. Follow-up assessments conducted eight weeks later showed no significant change in comprehension.
Planned comparisons on ability to generalize training across academic disciplines showed RT students improved from 20% to 60% correct. For these, two 2X5 mixed analyses of variance were conducted, one on social studies scores and another on science class scores with groups as the between-subjects variable, and phase as the within-subjects variable. Percentile rankings with the entire class were conducted as well and showed improvement among RT trainees compared to no change among control students, changing their status from bottom of the distribution to at least average standing. A standardized reading test administered three months after the conclusion of RT training showed the six treated students enjoyed an average gain of 15 months in reading comprehension, while vocabulary increased only one month.

As case studies, the six students provided Palincsar and Brown with additional material. One student, a minority with an IQ of 70, was four years delayed on standardized reading comprehension scores with a 0% ability to generate questions initially and baseline comprehension of 30%. He was unable to form a question until his ninth attempt but eventually gained 65 points on question-generating, scores of 80-90% on comprehension, and gained 20 months on the standardized test. A second student went from 30% to 90% correct on daily comprehension tests that required independent reading and was thrilled to go from the second to fiftieth percentile in her science class ranking, but failed to improve on the standardized test of comprehension. A third student had trouble mainly in comprehension during independent reading and her success there transferred well into other courses and to her standardized test score where she gained 15 months.
A second follow-up study was conducted by Palincsar and Brown following similar guidelines to the one described above, but using volunteer teachers and naturally occurring groups of student readers using resource room services. In this case, similar, but less dramatic results were found due to higher beginning means, with two groups reaching criterion comprehension levels in 13 days, one in nine days, and one in only five days. In the five-day group, researchers note that two of the four students performed well on the first day, thereby providing the two remaining students with excellent models that assisted their rapid assimilation of the use of strategies. Conclusions of success were based on the following eight points:

1. clear qualitative evidence of improvement in students' dialogues;
2. large and reliable quantitative improvement on comprehension tests;
3. effects were durable;
4. effects generalized to classroom settings;
5. training transferred to laboratory tasks in science;
6. improvements in standardized tests occurred for most students;
7. the intervention was equally successful in a natural classroom setting; and,
8. teachers were enthusiastic following use of RT and incorporated it into routine teaching repertoires.

Supplemental Instruction

From 1973 to 1998, Deanna Martin and others studied Supplemental Instruction through a number of quasi-experimental designs that, in most cases, compared the performance of a voluntary treatment group, the SI participants, with a control of non-
participants. Independent variables of motivation to participate, college entrance standardized test scores, high school percentile rank, prior academic achievement, ethnicity, and frequency of SI attendance were used in various studies. Dependent variables used included final course grades, percent of A & B final grades and D, F, or W grades, re-enrollment rates, GPA, and graduation rates. While research did not meet experimental design standards, results were replicated across many institutions, ethnicities, and courses. The six sets of data from UMKC include historical data; data controlled for motivation, prior academic achievement, ethnicity; frequency of SI attendance on mean final course grade; and longitudinal follow-up.

The population studied in each case was all students enrolled in courses in which SI was offered, both participants and non-participants. For purposes of interpretation, participants were defined as students who participated in one or more SI session during an academic term, with a one-session criteria chosen as a conservative figure to avoid skewing data in favor of SI by students who withdrew from the course. Evaluation was based on course rosters, grades, re-enrollment, graduation, and background data, and on two surveys—one on motivation, administered on the first day of the course and a second on SI participation, administered the last day of class. At UMKC, faculty members also provided students' scores on the first major test of the semester. The UMKC national SI director oversees all data collection, analysis, compilation, and dissemination of SI reports, using independent t-tests for final course grades, and chi square tests for nominal data in percentage of A and B's, and D, F and W's, and the percentage of re-enrollment.
SI results were provided with the caveat that studies reflect possible effects from independent variables such as different institutions, instructors, courses, SI leaders, criteria for assigning grades, and different abilities of groups who choose SI or do not choose SI. Regardless, the stability of SI results across all of these variables is considered proof of its efficacy. An example of results for academic achievement is provided from 1996-97, when 44.9% of students in SI classes participated in SI and had a higher percentage of A and B final grades (55.9% versus 44.1%), a lower percentage of D and F grades and withdrawals (16.7% versus 31.5%), and a higher mean final course grade (2.66 versus 2.35) than non-participants. Similar results were achieved each year.

In Martin's second study, a non-SI motivational control group was designed by selecting students who had strong motivation to attend SI but who subsequently learned that they had a work or school conflict. This group allowed statistical comparison of three independent groups: SI, Non-SI motivational control, and Non-SI. In this study, the following results were found:

1. SI participants have entry data of high school rank percentile and college entrance test scores similar to data of other groups;
2. SI participants have significantly higher average course grades compared to both non-SI groups (p<0.01); and,
3. SI participants have fewer D, F and W grades than either non-SI group (p<0.05).

A third study compared SI participants to non-participants based on previous academic achievement using high school rank and scores on college entrance tests and found that students in the lowest quartile used SI services at the same rate as the highest ranking group, with similar gains in course grades. The top quartile SI participants earned
an average grade of "B" while the overall average was "C" or "C+", and the lowest quartile earned an average grade of "C" where their previous-achievement peers who were non-participants had an average grade of "D." A fourth study showed similar results for African-American students where SI participants were compared to non-participants.

The results of the fifth study that compared frequency of attendance to final course grades showed what Martin termed, "unexpected results" (p. 125). As expected, non-SI students had the lowest mean final course grade (2.37), but the second-lowest group (2.64) was the small group of students who attended most often, 12 or more SI sessions. Since other groups showed increasing mean course grades with greater attendance, interviews were conducted that indicated some students had planned to withdraw from the course but persisted with assistance from SI. Confirming this data was the sixth study that indicates SI contributes to student persistence in terms of graduation and re-enrollment. One further study bears mentioning here. A supplemental study from the University of Texas (McGinty, 1989) compared time spent on SI activities to time spent in traditional discussion activities and found that the particular activities used in SI accounted for the positive results obtained.

While none of the research reported by Martin is convincing on its own, together, the volume of studies and results speak to the efficacy of the program. However, conspicuous by their absence are studies that investigate why some students do not use SI and any relationship to financial constraints, family obligations, or first generation status, or to comfort with social interaction or self-efficacy in the course.
Summary of the Review

This review of the literature addresses topics pertinent to a research design that used structured course assignments to elicit peer learning through behaviors of summarizing, clarifying, questioning, and predicting. As such, topics reviewed include peer learning and learning strategies as well as an overall look at research on learning, motivation, and aspects of instructional design. Special consideration was given to the two most similar models of learning from which the research borrowed heavily: Reciprocal Teaching, and Supplemental Instruction.

To summarize, people have an innate drive to learn and derive satisfaction from learning that stretches their existing abilities without overtaxing or underutilizing abilities, but which provide clear, proximal goals, and feedback. Learning relies on learners’ attention, retention, reproduction, and motivation processes, all of which occur first on a social or intramental plane before being internalized. Peer learning provides a safe environment where students can work together to organize and learn course materials and it also enhances students’ efficacy and provides opportunity for vicarious learning of skills and the use of learning strategies. Learning strategies that have been successful at the college level encourage students to identify the components of complex concepts (summarize, clarify), break down complex tasks into small units (study skill), ask themselves questions during reading and form hypotheses (predicting), read or listen for confirmation (feedback); devise informal feedback devices for themselves (generate questions); and focus on instructional objectives and directing their own study to meet course objectives (metacognition).
Because a high percentage of students procrastinate and become anxious when given loosely structured, high-risk, challenging assignments with little opportunity for feedback, instructors of difficult entry-level courses can enhance student learning and reduce attrition by providing structured course assignments that provide clear, proximal goals, feedback, and encourage students to use active learning strategies.

**Overall Weakness and Strengths; Avenues for Further Inquiry**

The research was based on well-documented facets of learning and on learning strategies that have been tried and proven over many years. Consequently, the review concentrated on providing a theoretical basis for activities that are already in use, and found them well-supported by past and recent research on the psychology of learning. Areas in which the review and research that it reviews are scanty are in the design of course assignments, the use of course assignments at the college level to produce desired connections between course materials and student learning, and the use of assignments to promote the use and understanding of learning strategies. While these are the focus of this study, the paucity of previous research in these areas point to opportunities for further inquiry.

In addition, an interesting area of study would be to ascertain what knowledge entering freshmen have regarding learning strategies, which students have the knowledge, how they came by that knowledge, and their attitude toward using strategies. Another potentially interesting study would involve the use of Supplemental Instruction in a comparison between current uses of SI and an alternative where SI was not optional for some students—those, for instance with pretest scores below a certain level, or for all
students during the first six weeks. With modifications that improve peer interaction and feedback, the current research could be expanded to challenging humanities or social science courses such as economics, logic, or others, and alternative types of course assignments substituted for those used here. For the most part, the review revealed that individual instructors are often innovative in meeting the needs of their students, but that few paradigms have been designed for widespread use to alternative situations. SI was partly designed to avoid infringing on instructors’ course design and to provide assistance for students in courses where significant portions of the learning required self-direction and autonomy. In contrast, the broad design of “writing across the curriculum” and more current emphasis on oral presentation recommend structured approaches to a variety of learning situations. The current research was used to investigate one way in which promotion of learning strategies can drive the design of course assignments. Further inquiry involving variations in assignment designs and educational situations with greater attention to the research structure will be discussed in Chapter 5.
CHAPTER 3
RESEARCH METHODOLOGY

The variance in rates of assimilation of learning among students in challenging college courses causes logistical concerns for instructors, academic problems for students, and retention concerns for institutions of higher education. Supplemental Instruction and similar programs have been successful in some college settings in reducing the variance, but tend to be costly and administratively complex. The current research is used to investigate the use of structured course assignments in leading students toward a more homogeneous rate of assimilation of both course content and the learning strategies that promote learning.

The methodology was designed to include a mix of experimental and naturalistic components to provide a more complete understanding of results. The primary experimental focus compared course grades of students who were given more highly structured homework assignments to the half of the class who served as a control and completed less structured assignments (the "if-when" factors). A second quantitative focus compared results of pre- and posttests of learning strategies to determine if differences occurred between the test and control groups. Naturalistic components of the research were used to investigate students’ perceptions of their learning and assimilation of learning strategies (the “how-why” factors), and instructors’ reactions to the use of structured assignments.

College Chemistry I was chosen to represent an historically difficult course for entering freshmen at Montana State University-Bozeman, and had been the most difficult
entry level course for some years according to university records. Since the research was conducted in an actual course with more than 600 students initially enrolled, the experimental conditions of the research were secondary to the educational goal of the situation. Although efforts were made to replicate teaching/learning paradigms such as Supplemental Instruction, the flexibility of the model was an innate condition for success of the research. The efficacy of each component of SI—working in a small group formats, modeling of learning strategies, collaborative peer learning, and the use of questions to stimulate summarizing, clarifying, question generating, and predicting responses—were already well-documented regarding their roles in assisting with student learning. The conditions and combinations of conditions necessary to learning in challenging courses such as college chemistry are less well understood. Additionally, traditional SI is a voluntary program in which self-motivated students participate, while students who are less-motivated, or who have less flexible schedules or who, for one reason or another decide not to avail themselves of the potential benefits of SI, do not participate. The research parameter removed the structure from the SI group meetings and replaced it with structure contained within the assignment itself—a change that also removed the voluntary aspect of SI. The research was designed to investigate whether these changes retained the benefits of SI or stressed the model beyond its limits. The qualitative or naturalistic components were included in the research design to add context-specific data to inform the findings in regards to human elements.

The data included between-groups measures that arose from potential differences in learning between students in Tuesday/Thursday labs and those in Wednesday/Friday labs who received different treatment in regards to homework assignments. The difference
was achieved by requiring students to work in groups and adding and/or rewording homework questions to require students to summarize, clarify, predict, or generate questions. The within-subjects measures arose from an inventory of ten study skills administered at the beginning of the semester and again at the end to three lab sections chosen through stratified random selection from each of the test and control groups. Demographic information was included for all students for comparison purposes. Qualitative instruments were used to interview the course instructors, teaching assistants, and a random selection of students. Instructor and teaching assistant interviews were conducted individually, while student responses were garnered through focus groups and telephone interviews.

In an average year at MSU-Bozeman, approximately 800 students enroll in Chemistry 131, a four-credit general chemistry course. In the fall, two lecture sections are offered with approximately 500 students total and twenty-five laboratory sections of 14-20 students each. An administrator estimated that 30 of the fall Chemistry 131 students would not participate in labs as they would be repeating the course or had already taken the less-rigorous Chemistry 121 course, and had achieved a satisfactory lab grade. Chemistry 131 consists of three 50-minute lectures per week and one 170-minute lab. The fall, 2002 professor said that chemistry labs were loosely related to lectures and were designed to teach discrete lab skills and provide an experiential forum for student learning. Lab benches are designed for four, but students work in groups of two and collaborate on lab reports. For several years, labs have begun with a 20-minute quiz on three problems taken from 12 assigned (but not graded or collected) the week before. In fall semester, 2002, 639 students registered for Chemistry 131, causing the total number
of labs to be increased to 32. By the end of the withdrawal period two weeks into the semester, 587 students remained enrolled in the course. Partially in response to the proposal for research involving homework assignments, and partly due to plans to improve student outcomes, lab quizzes were replaced by graded homework assignments.

The primary purpose of a phenomenological or naturalistic approach to inquiry is that of discovery, to determine the broader implications of a problem defined by its own parameters (Guba, 1978). In the current research, the problem had both an objective goal, that of eliciting use of a particular set of learning strategies in the experimental situation, and a subjective goal, that of achieving a method whereby instructors and students could use those strategies in common non-experimental situations. The experimental method outlined in this chapter required extra time and effort on the part of the instructor and students, with much of the burden falling to students through structured course assignments. The structure outlined required students to use SGCP strategies that may have been foreign to them and that required high-level thinking skills. However, they also served to organize and assist learning of difficult material. Research has shown that students who feel overwhelmed or cognitively inadequate experience agitation while those who receive needed support find learning more pleasant (Bandura, 1997).

Therefore, the naturalistic inquiry regarding participants' perceptions of the experimental activities and their reactions to them are of prime interest in determining whether the investment was worth the return, and if so, for which participants. To review, the research was designed to answer the following questions:

1. Are there significant differences in measures of students' learning outcomes between the treatment group in which homework assignments were structured to induce use of
learning strategies and those of the untreated group whose homework assignments were not specially structured?
2. Are there significant differences in pretest-posttest scores between the treatment group and the non-treatment group on measures of attitude and use of learning strategies?
3. Are the experimental strategies manageable from the instructor's perspective in terms of ease of use and cost?
4. Do students gain in understanding of learning strategies by completing course assignments that are structured to encourage their use?

Methodology

Participants

Participants of the experimental portion of this study were 587 students enrolled in Chemistry 131 at Montana State University-Bozeman during the fall semester, 2002. Students self-enrolled in one of two lecture sections offered, 9:00 a.m. and 1:00 p.m. Monday-Wednesday-Friday, and for one laboratory section, offered at various times, Tuesday through Friday. Students were assumed to have met the course prerequisite which was two years of high school math to include algebra or a math ACT score of 25 or higher, an SAT score of 570 or higher, or completion of MSU’s Math 105, Algebra for College Students. The course had a high percentage of entering freshmen but also included upper classmen who were taking the course for the first or second time (see Table 3). Additional data showed that the fall class consisted of 62.5% males and 37.5%
females from a variety of academic majors (see Table 4). Although ages ranged from 16 to 44, 94% were less than 25 years old, giving the class a mean age of 19.66 years.

Table 3: Frequency of Participants by Grade Level

<table>
<thead>
<tr>
<th>Year in College</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen</td>
<td>451</td>
<td>76.8</td>
</tr>
<tr>
<td>Sophomores</td>
<td>80</td>
<td>13.6</td>
</tr>
<tr>
<td>Juniors</td>
<td>30</td>
<td>5.1</td>
</tr>
<tr>
<td>Seniors</td>
<td>15</td>
<td>2.6</td>
</tr>
<tr>
<td>Post-graduate students</td>
<td>11</td>
<td>1.9</td>
</tr>
<tr>
<td>Total #</td>
<td>587</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 4: Frequency of Students by Major

<table>
<thead>
<tr>
<th>Major</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>223</td>
<td>38.0</td>
</tr>
<tr>
<td>Science</td>
<td>154</td>
<td>26.2</td>
</tr>
<tr>
<td>General Studies</td>
<td>73</td>
<td>12.4</td>
</tr>
<tr>
<td>Agriculture</td>
<td>62</td>
<td>10.6</td>
</tr>
<tr>
<td>Health &amp; Human Development</td>
<td>46</td>
<td>7.8</td>
</tr>
<tr>
<td>Other</td>
<td>29</td>
<td>5.0</td>
</tr>
<tr>
<td>Total #</td>
<td>587</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The instructor was an associate professor tenured in his department who has taught the course for seven years. Teaching assistants were a mix of undergraduate and graduate
students who had previously taken and passed Chemistry 131 or an equivalent course at another university. Some teaching assistants had prior experience teaching chemistry labs, and all receive remuneration for their work. Their responsibilities include attending weekly Teacher’s Assistant (TA) meetings run by a professional lab coordinator, instructing 1-4 labs per week, and assisting students to learn in the chemistry help center.

Instrument

The Learning and Study Strategies Inventory, or LASSI, was used in this research as pretest and posttest measures of students’ use of study skills. The LASSI was developed in 1987 by Claire Weinstein as part of the Cognitive Learning Strategies Project at the University of Texas at Austin. Over a nine-year period beginning in 1978, expert judges and various pilot tests reduced an original pool of 645 items to ten categories that encompassed the various topics experts referred to as “study skills” or “learning strategies” (Weinstein, 1987). The ten categories tested by the LASSI are attitude, motivation, time management, anxiety, concentration, information processing, selecting main ideas, study aids, self testing, and test strategies. In the final version of the original LASSI, a total of eight questions were listed for nine of the ten categories, with the tenth, selecting main ideas, having five questions for a total of 77. Five possible answers are provided for each question on a Likert scale that ranges from “very much typical of me” to “not at all typical of me.” The validity of the LASSI was examined through several approaches. According to Weinstein, comparison studies were conducted using similar tests or subscales where possible, and the LASSI itself was subjected to repeated tests of user validity at more than 30 colleges and universities. Preliminary test-retest reliability
using a 3- to 4-week interval showed a reliability factor of .88. In her work at the Cognitive Learning Strategies Project, Weinstein used the inventory as a diagnostic tool for more than 1000 students per year for remediation, enrichment, and pretest-posttest evaluation of student progress. The validity and reliability of the instrument became widely accepted and used across the country as a diagnostic, prescriptive, and evaluative tool.

The second edition of the LASSI, published in 2002, was a five-year process designed to replace outdated items from the 1987 version such as expressions that are no longer in common use, and add references to newer technology such as the web. In addition, it reflects current research findings on learning and learning strategies such as the importance of metacognitive oversight of learning. On some scales, the newer LASSI “samples more broadly from the domain of academic tasks required of a college student” (Weinstein & Palmer, 2002, p. 16). The 2nd Edition has a total of 80 questions, eight from each of the ten scales measured, and has improved psychometric properties with alpha coefficients of .73 to .89 (Weinstein & Palmer, 2002). Although the ten subscales of the LASSI are interrelated due to the underlying “framework of strategic learning” (Weinstein & Palmer, 2002, p.4), each scale is primarily related to one of three types of strategic learning: skill, will, or self-regulation.

The skill component of learning is measured through three scales: information processing, selecting main ideas, and test strategies. “Information processing” involves organizing learning in meaningful and memorable ways that bridges what students know with what they need to learn. Information processing strategies include paraphrasing, summarizing, creating analogies, outlining, idea mapping, generating questions, and
predicting what will be on a test and how it will be worded. The information processing scale checks students’ ability to comprehend, reason, and elaborate. “Selecting Main Ideas” is an ability central to understanding how information is related to each other and how it fits together in a coherent and memorable way. It involves recognizing important concepts and supporting details, and knowing what to study and why it is important. The scale for selecting main ideas asks whether students can separate concepts or key points from supporting details and knows, for instance, what is important to underline in a textbook. The third skill component is called “test strategies.” The test strategies scale measures students’ skills in preparing to take tests and in taking tests. Some of these skills are choosing and organizing information to study, knowing how to study for different courses, reviewing answers to possible essay questions, and creating strategies to assist memorization.

Three of the LASSI scales measure components related to the “will” portion of strategic learning. These are anxiety, attitude, and motivation. The “anxiety” scale measures the degree to which students worry about school and their performance on academic tasks. Anxiety interferes with the enjoyment of learning and with learning itself by interfering with students’ attention, memory, concentration, and ability to think. In addition, anxiety contributes to a lack of persistence, allowing students to become easily discouraged by low grades. The second will measure on the LASSI scale, “attitude,” measures students’ clarity of educational goals and interest in them. Attitude affects persistence factors such as trying alternative methods when the first doesn’t work, and putting in enough study time in hours, days, weeks, months; it also affects the ability to remember information and to recognize the importance or meaningfulness of concepts.
The LASSI measure of attitude asks questions such as, "Is school really important or worthwhile to you?" "Motivation," the third measure of will, is similar to attitude but affects the task at hand where attitude applies to learning in general. Attitude answers why you might want to learn; motivation is when, or why you want to do it now. The motivation scale assesses diligence, self-discipline and willingness to stay on task.

The other four LASSI scales—concentration, self-testing, study aids, and time management—measure the self-regulation component of strategic learning.

"Concentration" skills are a combination of focusing attention on learning activities such as reading texts, listening in class and studying, and avoiding becoming distracted by one's own thoughts, emotions, and feelings. The concentration scale measures students' ability to focus attention on academic tasks and to avoid distracting thoughts. "Time Management" involves making decisions and choices about when to attend to the tasks of education and how much time to delegate for them. Some students choose to plan other facets of life such as jobs, home-life, and recreation, then fit classes and studying around them. The time management scale addresses organizational issues and the use of time for academic tasks. "Study aids" draw attention to important material and help with understanding and memory. Many textbooks abound with study aids, instructors provide others, and students can create their own, highly effective aids. The LASSI scale for study aids measures students' use of support techniques and whether they create and organize study materials. The final self-regulatory aspect of strategic learning is termed "self-testing." The self-testing scale assesses students' attitude regarding their degree of preparedness for classes and tests and their use of review to monitor levels of learning and understanding. Essentially this scale measures whether students use active learning
strategies to organize new understandings with previous knowledge, to make connections, and interpret information into meaningful questions and answers. The self-testing scale asks questions such as whether students stop periodically while reading to mentally review what was said.

**Validity and Reliability.** As with the first version, the 2nd edition of the LASSI began with an item pool, revisions by a panel of experts, and pilot testing before proceeding to field testing. The ten scales do not provide a composite score but are considered as separate measures that show the individual strengths and weaknesses of students in regards to their study strategies. Therefore, each measure was tested for its own reliability coefficient. The following results (see Table 5) were provided in the User’s Manual for those administering the Learning and Study Strategies Inventory 2nd Edition. Measures of inter-scale correlations varied from a high of 0.670 between concentration and time management, and a low of 0.069 between study aids and anxiety. The average inter-scale correlation was 0.448, reflecting the interconnectedness of strategic learning skills and the limitations of a 5-response Likert scale.

**Structured Homework Assignments**

The instructional difference between the test and control groups was entirely comprised of two differences in homework assignments between the groups. Students who attended Chemistry 131 labs on Wednesdays or Fridays were given more highly structured assignments than those in Tuesday or Thursday labs, and they were encouraged more strongly than the control group to work with classmates on homework assignments. To accomplish the differences, one set of homework problems was
Table 5: LASSI Scale Statistics*

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>Scale Mean</th>
<th>Standard Deviation</th>
<th>Coefficient Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety</td>
<td>25.52</td>
<td>6.95</td>
<td>.87</td>
</tr>
<tr>
<td>Attitude</td>
<td>33.41</td>
<td>4.29</td>
<td>.77</td>
</tr>
<tr>
<td>Concentration</td>
<td>26.97</td>
<td>6.01</td>
<td>.86</td>
</tr>
<tr>
<td>Information Processing</td>
<td>27.25</td>
<td>5.66</td>
<td>.84</td>
</tr>
<tr>
<td>Motivation</td>
<td>31.19</td>
<td>5.32</td>
<td>.84</td>
</tr>
<tr>
<td>Self Testing</td>
<td>24.53</td>
<td>6.15</td>
<td>.84</td>
</tr>
<tr>
<td>Selecting Main Ideas</td>
<td>28.06</td>
<td>6.10</td>
<td>.89</td>
</tr>
<tr>
<td>Study Aids</td>
<td>25.25</td>
<td>5.56</td>
<td>.73</td>
</tr>
<tr>
<td>Time Management</td>
<td>26.08</td>
<td>6.30</td>
<td>.85</td>
</tr>
<tr>
<td>Test Strategies</td>
<td>29.13</td>
<td>5.08</td>
<td>.80</td>
</tr>
</tbody>
</table>

*Scale Statistics for the final version of each scale of the LASSI, 2nd Edition. (Weinstein & Palmer, 2002).

constructed for the entire class, then questions and suggestions were added for the test group using terms previously identified as effective in eliciting the desired behaviors.

The Structure: The structure component of the Chemistry 131 assignments involved three areas. The primary change was the rewording of homework questions in a manner that required students to use summarizing, clarifying, generating questions, and predicting strategies. The other two changes were inclusion of suggestions regarding effective study methods beyond those provided to both groups in the first homework assignment (see Appendix A), and added encouragement to work on homework in groups with classmates (see Appendix A). The format by which assignments were reworded followed joint components of the Reciprocal Teaching and Supplemental Instruction models. In both cases, and in the underlying research, findings showed that asking students to perform the concrete activity of summarizing also asked that students attend to the content and their understanding of that content (Palincsar & Brown, 1984).
Similarly, "clarify" asks that students critically evaluate the content, predicting requires the drawing and testing of inferences, and questioning involves analyzing the importance of content and self-monitoring one's own comprehension relative to the content (Palincsar & Brown, 1984). Throughout the semester, two versions of homework problems were composed with variations supplied for the test group. Some problems were identical while others had specific additions such as, "define this term in your own words," "explain your answer," or "explain how these reactions are similar and how they are dissimilar." In one case the following was added:

For questions eight and nine, note the following:
  a) What information is necessary to solve this problem?
  b) Predict what sort of product will result from this reaction.
  c) In general terms, what kind of chemical change is occurring? (An example might be "all alkali metals react with water to form hydroxide compounds and hydrogen.")

Other more specific examples of differences follow (see Table 6). The first of these examples in particular adds significant content to the homework question and is therefore likely to add significant length to the time it takes to answer the question. As mentioned above, many questions were not altered at all, so the overall length of the homework assignment was not excessive in comparison with the control group. However, the research paradigm did not concern itself with time on task because it attempted to emulate the benefits of Supplemental Instruction programs through use of assignments and did not compare two forms of treatment. The question of whether the supplemental assignments required too much of students' time was investigated only through qualitative interviews.
Table 6: Comparison of Structured and Unstructured Homework Questions

<table>
<thead>
<tr>
<th>Original question</th>
<th>Structure added</th>
</tr>
</thead>
<tbody>
<tr>
<td>According to the Bohr theory of the hydrogen atom, a) what process is occurring when excited hydrogen atoms emit radiant energy of certain wavelengths and only those wavelengths?  b) What kind of process corresponds to the absorption of light of certain wavelengths by hydrogen atoms?</td>
<td>For Bohr’s formula ( \Delta E=E_f-E_i=h\nu ), a) define each term;  b) explain when you would use this formula;  c) what you can conclude when ( \Delta E ) is a positive or negative value?  d) Can Bohr’s model be used to explain energy states for atoms of all elements?  Why or why not?  e) In terms of Bohr’s theory, explain the process that occurs when excited hydrogen atoms emit radiant energy of certain wavelengths and only those wavelengths?  f) What kind of process corresponds to the absorption of light of certain wavelengths by hydrogen atoms?</td>
</tr>
<tr>
<td>Irradiating luggage with neutrons, which are able to pass straight through the bags, is sometimes used to detect explosives. Calculate the velocity of a neutron that has a characteristic wavelength of 1.02Å. (The mass of a neutron can be found behind the front cover of Brown, LeMay and Bursten.)</td>
<td>Note that the mass of a neutron, given in side the front cover of the Brown, LeMay and Bursten book, is 1.0086649 amu or 1.6749286 x 10^{-24} g. Which value will you use in the following problem, and why?  Irradiating luggage with neutrons, which are able to pass straight through the bags, is sometimes used to detect explosives. Calculate the velocity of a neutron that has a characteristic wavelength of 1.02Å.</td>
</tr>
<tr>
<td>Sketch the shape and orientation of the following types of orbitals: a) s;  b) p(<em>x);  c) d(</em>{xy}).</td>
<td>Sketch the shape and orientation of the following types of orbitals: a) s;  b) p(<em>x);  c) d(</em>{xy}).  d) What part of the periodic table contains elements whose electron orbitals are limited to s, p, and d subshells?</td>
</tr>
</tbody>
</table>
conceptualization, and theories and chemical language (VerBeek & Louters, 1991). Problem-solving included students’ question-asking capability and ability to go beyond simple algorithms; and chemical language included facts, concepts, and rules. Under the usual SI structure, the use of study skills and strategies appropriate to the particular subject under study would be modeled by the peer leader and be explicitly suggested to students during SI meetings. In the current research, study strategies were embedded in homework assignments either as part of some questions or as separate suggestions. The initial homework assignment for both the control and the test participants included a description of the Lockie and Van Lanen suggestions and other recommended study skills (see Appendix A). This was the most comprehensive mention of study skills provided to students, but for the test group, additional specific suggestions were embedded in assignments. On the second homework assignment, the following study suggestions were given:

1. Decide to memorize the list of strong acids, strong bases; and the weak base NH₃.
2. Spend five minutes thinking about how to organize the information mentally, then a few more minutes memorizing.
3. When you think you’ve got it, see if you can re-create the list on fresh paper without looking. Many students can do so perfectly after only three tries. If you are successful, check yourself again tomorrow.
4. During the test, “dump” memorized material onto scrap paper before you look at any test questions, because thinking interferes with remembering.

On another question in the same assignment, the following study suggestion was added:
"Before answering this question, review rules for assigning oxidation numbers and consider which of the species is an atom in its elemental form, a monatomic ion, a polyatomic ion, etc. Review the ‘oxygen rule’ and the ‘hydrogen rule.’" In these various ways, students were asked to apply study strategies to course content.

The third component of the structure added to assignments of the test group was strong encouragement to work with classmates to complete assignments. On the first assignment, an entire page was devoted to discussing group work with particular attention to how to find classmates and locations available for meetings (see Appendix A). Some of these were rooms reserved for use at particular times by students in the Chemistry 131 course, and others were campus locations that could accommodate the interactions of small groups of students. The only differences distinguishing the group instructions for the test and control groups were the first two sentences. Wednesday/Friday lab students were told, “You must work with at least one other Chem 131 student to complete homework for full credit (groups of three are best). Please put the following information at the top of all homework assignments, and have others in your group initial their names.” In contrast, the Tuesday/Thursday lab students were told, “Working in groups is optional for students in your lab section. If you work with another Chem 131 student (or more) please note their names (for statistical purposes only) at the top of your homework assignments as follows:” Although homework was distributed in lectures, it was returned to lab instructors who were also responsible for grading. Therefore students were able to discuss problems with their teaching assistants, who were coached to encourage students to work in groups but to be lenient with those who expressed concerns about their ability to do so. Following the second midterm and
beginning with homework for Chapter 6, the heading on the homework for the test group changed to “Working in groups is now optional but recommended for students in your lab section. If you work with another student (or more) please note their names (for statistical purposes only) at the top of your homework assignments as follows:”

Qualitative Instruments

Different qualitative instruments were developed to gather information from the various participants of the study. The course instructor played an active role in designing the study and carrying out the semester-long experiment, yet he was also a prime focus of the study in that his experience of the changed structure helped to determine the overall results. Therefore, his thoughts and ideas were assessed in an interview at the end of the semester, and were part of the field notes collected throughout the semester; both added significantly to the naturalistic component of data collection. The content of the interview questions was primarily determined by the third research question: Are the experimental strategies manageable from the instructor’s perspective in terms of ease of use and cost? The full text of the instrument is included as Appendix B. The third question was also the prime focus of interviews held with laboratory teaching assistants, but since they also work at the Chemistry Help Center where students seek assistance with homework, their interviews included questions concerning students’ attitudes and abilities in regards to homework. This involved research question four, which asked, do students gain an understanding of learning strategies by completing course assignments that are structured to encourage their use? Additional data was garnered from an informal focus group that occurred at a late semester TA meeting. The TA and student interview instruments are
also in Appendix B. Students were interviewed using two different instruments. The first was for use with small focus groups of students during final lab meetings. The second was for individual phone interviews and addressed issues raised during focus group discussions.

Each qualitative instrument was written in the open-ended questioning style common to naturalistic research. Questions that were leading or which invited a yes or no answer were avoided, and preference given to wording that invited a thoughtful, insightful response to questions raised prior to the research, during the semester, or during focus group interviews. Particular issues attended to the research questions, but as results of the quantitative portion of the research became more clear, and points previously thought to be minor gained in importance.

**Experimental Procedure**

At the beginning of the semester, the course instructor flipped a coin and determined that the 276 students participating in Wednesday or Friday labs would be the treatment group who were given the more highly structured homework assignments (47.0% of the class) and the 296 students participating in Tuesday or Thursday labs would serve as the control group (50.4% of the class). The 15 students enrolled in Lab Section 50 (2.6% of the class) were exempt from labs and were free to choose a lab section to which they would submit homework, and so were tracked as a separate group. A second selection process was conducted to choose lab groups for administering the LASSI, a study skills assessment instrument. For financial and practical purposes, use of the LASSI was limited to stratified cluster samples of students. Lab section numbers were separated into
four groups for each lab day, Tuesday through Friday. After one lab was selected via a blind drawing from each pot, the remaining Tuesday and Thursday numbers were mixed for a final drawing, and a final Wednesday/Friday, number was chosen in the same way. The researcher attended the first scheduled TA meeting prior to lab meetings and arranged to have students in each of the six selected lab sections complete the instrument at the close of their first scheduled lab meeting. It took approximately 20 minutes for most students to complete the instrument; 83 completed instruments were collected in class. Students were not allowed to grade their own LASSI’s as that process can be time consuming and would then require interpretation that might confound posttest use. Instead, individual scores were entered into a computer model and transferred to a spreadsheet for compilation and comparison to posttest scores. Demographic data including age, gender, year in school, and major were collected from the University information system.

In previous semesters, the instructor assigned homework problems from the text (for which students were able to purchase a solutions manual) but, in lieu of collecting and correcting assignments, gave weekly quizzes on three of the assigned problems. In the fall of 2002, the instructor devised two sets of homework problems for each chapter, first compiling problems from a variety of sources, then adding structural changes intended to encourage use of the SGCP learning strategies. The resulting sets of problems were printed on red paper for Tuesday/Thursday lab students and green paper for Wednesday/Friday lab students and were distributed in lecture classes. As in previous semesters, each lab instructor selected three problems for grading purposes. Graded homework was returned to students in a central area near the lecture hall and weekly
homework solutions were available for purchase. During the final lab session of the semester, students from the same six lab sections that were given the LASSI as a pretest completed an identical posttest instrument. In each section, a few students had added into the lab and so had not completed the pretest; these took part in focus groups as part of the naturalistic component of the research. Focus group interviews were taped and transcribed. LASSIs were also delivered or mailed to students who had completed an instrument in September but had since changed lab sections or dropped the course.

Following the final lecture, the researcher gave separate interviews to the course instructor and two of the teaching assistants; these interviews were also recorded and transcribed. Finally, a random selection of students and some who were purposively selected were surveyed by telephone.

Assessment

The mixed method research design has inherent differences such as the philosophical basis, methods and scope, whether conditions are controlled or occur naturally, and even the purpose and scope of the research (Guba, 1978). Some investigators approach the two types in an exclusionary manner but others find the two can be complementary when each is used as it was intended, such as conventional inquiry to verify or refute theories and to reduce information to a usable form, and as an investigative tool of naturalistic inquiry that reveals and informs underlying process and confounding details. The current research used a mixed methodology in which quantitative measures tested the effects of structured assignments on learning outcomes (see A-C in Figure 1) the use and
understanding of learning strategies (A-B in Figure 1) versus the less structured assignments of the non-treatment group.

**Figure 1: Model of the Research Design**

A triangulation of naturalistic methods was also used to gain insight and provide contextual background to the results. The strong theoretical basis for the research lends credibility to both reductionist and expansionist methods, because while a strong precedent for the current research has been set, the literature review shows gaps regarding instruction and use of learning strategies through homework assignments and the assimilation of learning outcomes as a result of variations in homework assignments.

Assessment techniques varied according to the research questions under study. Empirical testing of changes in students’ study skills were compared for both within subject and between group differences. Because the LASSI yields 10 scores for each student and is not reduced to a composite score, independent and dependent t-tests were conducted on each of the ten measures. Demographic descriptives proved valuable as factors in contextual understanding of the paradigm and for correlation purposes. T-tests were also used to compare the number of study partners that students reported on homework assignments. Quantitative assessment results were used to answer the first two research questions:
1. Are there significant differences in measures of students' learning outcomes between the treatment group in which homework assignments were structured to induce use of learning strategies and those of the untreated group whose homework assignments were not specially structured?

2. Are there significant differences in pretest-posttest scores between the treatment group and the non-treatment group on measures of attitude and use of learning strategies?

Qualitative interviews and focus groups provided insight into the remaining two questions:

3. Are the experimental strategies manageable from the instructor's perspective in terms of ease of use and cost?

4. Do students gain in understanding of learning strategies by completing course assignments that are structured to encourage their use?

**Significance of the Study**

The academic experiences of entry-level college students affect their perception of academic fit and the consequent choices that they make. The review of literature regarding study skills and the use of study strategies indicate that students' approaches to their studies vary widely and that many, probably the majority of students, have not had formal training to supplement their experiential approach to learning. In addition, instructors lack formal training in devising effective course assignments that promote learning and the use of effective study skills. The study promotes discussion of a largely ignored area and adds empirical and phenomenological data to the field.
Ideally, the findings of the current research would be similar enough to Supplemental Instruction, the program on which the study is modeled, to make claims such as the following found in the SI Handbook of 1998:

1. Students participating in SI within the targeted historically difficult courses earn higher mean final course grades than students who do not participate in SI. This is still true when differences are analyzed, despite ethnicity and prior academic achievement.

2. Regardless of ethnicity and prior achievement, students participating in SI succeed within the course at a higher rate (withdraw at a lower rate and receive a lower percentage of D or F final course grades) than those who do not participate in SI.

3. Students participating in SI persist at the institution (re-enrolling and graduating) at higher rates than students who do not participate in SI.

In less formal literature, SI also claims to support faculty as they maintain high standards and expectations for course work, and to support students in learning and developing successful study strategies. A similar rate of effectiveness with new dimensions of cost-effectiveness and manageability would be highly significant in terms of retention, teaching, and learning.

Summary

The high rate of failure and withdrawal from challenging entry-level college science courses results in part from difficult content and diversity of student preparation, but also from transitional issues such as reduced course structure, greater anonymity, and ignorance regarding methods of strategic learning. The current research addresses these
issues through homework that forces students to use effective learning strategies and encourages them to work with fellow students. The course under study included more than 500, or 90%, freshmen and sophomores with a high percentage of engineering and science majors. The treatment group was chosen by the toss of a coin to include all 276 students who attended Wednesday or Friday labs while the 296 students in the non-treatment group served as a control. Students in both groups included an even distribution of lecture sessions, age groups, and majors. Approximately 10% of the class from three of the treatment labs and three non-treatment labs were chosen by stratified cluster sampling to complete pre- and posttests on learning skills at the beginning and end of the semester. Statistical use of dependent paired sample, and independent t-tests on the learning skill inventories and 2X2 ANOVA and independent t-tests on chemistry scores such as test, homework, and lab scores were used to compare groups in regards to learning outcomes. Chi square tests were used to compare grade distributions and correlations to check relationships among demographic features and course outcomes. Results were qualified through the use of interviews and focus groups to determine how the re-wording of homework affected assimilation of content and study skill strategies by students, and ease of implementation by the instructor.
CHAPTER 4

RESEARCH FINDINGS

Most college students and instructors are aware that there are particular study skills that help students to learn. However, for the most part, when students delegate time for studying, they employ a personal formula that has evolved more from trial and error than from understanding the science of learning (Najar, 1999; Resnick, 1987). For their part, instructors tend to focus efforts on overt teaching tasks—preparing lectures, designing class assignments, and choosing good texts—rather than in directing how students learn (McKeachie, 1995). Yet the historically difficult nature of courses like college chemistry leaves less room for diversity of students’ educational backgrounds (Martin, 1973; Muraskin, 1997). Some students do not have adequate understanding or knowledge of learning strategies to succeed in these courses (Martin, 1973), and do not find time to self-direct themselves on auxiliary learning beyond assigned tasks. Research shows that the use of these strategies can be adopted and learned (Palincsar & Brown, 1984), especially when students’ peers are using them (Martin, 1973), and that students will find time for assigned learning tasks (McKeachie, 1995). Within this framework, the research was designed to investigate the use of specially structured homework assignments in a general chemistry course to improve learning and the use of study strategies.

Using a mixed design, four research questions operationally defined the issues under investigation: In the first of these, quantitative analysis of students’ test scores and course grades was used to determine if significant differences occurred between measures
of outcomes of students in the treatment group whose homework questions were more highly structured and those in the non-treatment group, whose assignments were not highly structured. Treatment and non-treatment groups served as the independent factor with demographic factors as covariates. The second question asked if differences occurred in pretest and posttest scores between the treatment and non-treatment groups on measures of attitude and use of learning strategies. This portion of the quantitative analysis was based on students’ responses to the Learning and Study Strategies Inventory, or LASSI, which was administered in September and again in December to stratified cluster samples of students. Dependent and independent t-tests were used to measure within-group and between-groups variance on each of the ten subscales of the instrument.

Qualitative methods were used to gain insight into the final two research questions of 1. whether the experimental strategies were manageable from the instructor's perspective in terms of ease of use and cost, and 2. if students gain in understanding of learning strategies by completing course assignments that are structured to encourage their use. This chapter provides research results for each question and a discussion of the meaning in terms of the participants and the literature, with broader implications discussed in Chapter 5.

Results of Data Analysis

Research Question 1

Are there significant differences in measures of students’ learning outcomes between the treatment group in which homework assignments were structured to induce
use of learning strategies and those of students whose homework assignments were not specially structured? Statistical analysis of participants’ mean course scores showed that there was not a significant difference in means between the structured homework group and those whose homework was not structured. A third group that consisted of only 15 students, or 2.5% of the class, and who were not required to participate in labs so were neither part of the treatment or non-treatment groups, had the lowest course mean, while students in the treatment and non-treatment groups had nearly identical course means. Further, t-tests comparing scores for each of the four midterm tests, the final exam, and students’ composite grade for the course were statistically equivalent for the treatment and non-treatment groups.

Figure 2: Mean Grade Percentage by Group

Midterm and final exam data reveal that test means were statistically similar for the treatment and non-treatment groups, and that there were differences in standard deviation trends among the groups. An examination of the data in Table 7 reveals two interesting
trends. The more obvious trend is that test scores earned by the small third group of students varied widely, resulting in a large standard deviation. Approximately half (eight) of these students were repeating the course due to unacceptable prior grades with two of these enrolled in Chemistry 131 for the third time. Nine students took the less rigorous Chemistry 121, a course that is not a prerequisite, before taking 131, and four of the nine were also repeating Chemistry 131. Group 3 students were 53.3% female and 46.6% male, contrasting with the overall class which was 37.5% female and 62.5% male. Moreover, six of the nine students in Group 3 who took Chemistry 121 were female (66.6%) and three male.

Table 7: Students’ Mean Test Scores and Mean Final Grades by Group

<table>
<thead>
<tr>
<th></th>
<th>Mean Scores</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test 1</td>
<td>Test 2</td>
<td>Test 3</td>
<td>Test 4</td>
<td>Final Exam</td>
<td>Final Grade</td>
</tr>
<tr>
<td>Treatment Group 1</td>
<td>N</td>
<td>276</td>
<td>276</td>
<td>273</td>
<td>269</td>
<td>268</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>68.28</td>
<td>70.80</td>
<td>67.07</td>
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<td></td>
<td>SD</td>
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<td></td>
<td>SE</td>
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<td>1.26</td>
<td>1.30</td>
<td>1.37</td>
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</tr>
<tr>
<td>Non-treatment Group 2</td>
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<td>296</td>
<td>294</td>
<td>284</td>
<td>281</td>
<td>281</td>
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<tr>
<td></td>
<td>Mean</td>
<td>67.58</td>
<td>72.18</td>
<td>67.65</td>
<td>65.33</td>
<td>65.65</td>
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<tr>
<td></td>
<td>SD</td>
<td>18.19</td>
<td>19.87</td>
<td>20.03</td>
<td>19.20</td>
<td>20.70</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>1.06</td>
<td>1.16</td>
<td>1.19</td>
<td>1.15</td>
<td>1.24</td>
</tr>
<tr>
<td>Non-Lab Group 3</td>
<td>N</td>
<td>15</td>
<td>15</td>
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<td>65.80</td>
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<td>58.64</td>
<td>50.07</td>
<td>53.57</td>
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<tr>
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<td>SD</td>
<td>26.21</td>
<td>26.15</td>
<td>28.34</td>
<td>32.11</td>
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<td>6.75</td>
<td>7.57</td>
<td>8.58</td>
<td>7.61</td>
</tr>
<tr>
<td>Totals</td>
<td>N</td>
<td>587</td>
<td>585</td>
<td>571</td>
<td>564</td>
<td>563</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>67.87</td>
<td>71.30</td>
<td>67.15</td>
<td>64.10</td>
<td>64.83</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>18.78</td>
<td>20.55</td>
<td>20.96</td>
<td>21.27</td>
<td>22.04</td>
</tr>
<tr>
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<td>SE</td>
<td>0.78</td>
<td>0.85</td>
<td>0.88</td>
<td>0.90</td>
<td>0.93</td>
</tr>
<tr>
<td>Treatment &amp; Non-</td>
<td>df</td>
<td>570</td>
<td>568</td>
<td>555</td>
<td>548</td>
<td>547</td>
</tr>
<tr>
<td>treatment Groups</td>
<td>t sig.</td>
<td>0.447</td>
<td>-0.808</td>
<td>-0.331</td>
<td>-0.997</td>
<td>-0.586</td>
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</tbody>
</table>
The second trend is less obvious but relevant to the focus of this study. The test and final grade scores of the treatment and non-treatment groups of students were not statistically different, but an important difference was found. As indicated by measures of standard deviation among test scores of the first group, variability among students who received the treatment increased as the course progressed. In addition, the completion rate of the structured-homework students was greater than that of the non-structured group, creating a positive skew of grades, but also lowering the overall mean. A MANOVA test of between-subject effects (see Table 9) indicated that group alone did not account for significant differences in measures of learning outcomes but that gender and group together did affect outcomes, and that homework scores Table 8) were significantly different by gender.

Table 8: Pairwise comparisons from the MANOVA results in Table 9.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(I) sex of participant</th>
<th>(J) sex of participant</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.(a)</th>
<th>95% Confidence Interval for Difference(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade%</td>
<td>1 = Male</td>
<td>2 = Female</td>
<td>.253</td>
<td>1.558</td>
<td>.871</td>
<td>-2.807, 3.313</td>
</tr>
<tr>
<td></td>
<td>2 = Male</td>
<td>1 = Female</td>
<td>-.253</td>
<td>1.558</td>
<td>.871</td>
<td>-3.313, 2.807</td>
</tr>
<tr>
<td>Lab grade</td>
<td>1 = Male</td>
<td>2 = Female</td>
<td>-2.896</td>
<td>1.587</td>
<td>.069</td>
<td>-6.013, .222</td>
</tr>
<tr>
<td></td>
<td>2 = Male</td>
<td>1 = Female</td>
<td>2.896</td>
<td>1.587</td>
<td>.069</td>
<td>-.222, 6.013</td>
</tr>
<tr>
<td></td>
<td>1 = Female</td>
<td>2 = Male</td>
<td>-4.508(*)</td>
<td>1.925</td>
<td>.020</td>
<td>-8.289, .727</td>
</tr>
<tr>
<td>Homework</td>
<td>2 = Male</td>
<td>1 = Female</td>
<td>4.508(*)</td>
<td>1.925</td>
<td>.020</td>
<td>.727, 8.289</td>
</tr>
<tr>
<td></td>
<td>1 = Male</td>
<td>2 = Female</td>
<td>1.315</td>
<td>1.545</td>
<td>.395</td>
<td>-1.720, 4.350</td>
</tr>
<tr>
<td>Test Ave</td>
<td>1 = Male</td>
<td>2 = Female</td>
<td>-1.315</td>
<td>1.545</td>
<td>.395</td>
<td>-4.350, 1.720</td>
</tr>
</tbody>
</table>

Based on estimated marginal means
* The mean difference is significant at the .05 level.
a Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).
Table 9: Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>Grade%</td>
<td>1234.559(a)</td>
<td>3</td>
<td>411.520</td>
<td>1.343</td>
<td>.260</td>
</tr>
<tr>
<td></td>
<td>Lab gr</td>
<td>2068.454(b)</td>
<td>3</td>
<td>669.485</td>
<td>2.168</td>
<td>.091</td>
</tr>
<tr>
<td></td>
<td>HMWRK</td>
<td>4977.338(c)</td>
<td>3</td>
<td>1659.113</td>
<td>3.547</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td>Tst Ave</td>
<td>1193.613(a)</td>
<td>3</td>
<td>397.871</td>
<td>1.320</td>
<td>.267</td>
</tr>
<tr>
<td>Intercept</td>
<td>Grade%</td>
<td>2525399.58</td>
<td>4</td>
<td>2525399.58</td>
<td>8240.623</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Lab gr</td>
<td>3380801.06</td>
<td>1</td>
<td>3380801.06</td>
<td>10628.63</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>HMWRK</td>
<td>2936692.41</td>
<td>5</td>
<td>2936692.41</td>
<td>6277.988</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Tst Ave</td>
<td>2449858.79</td>
<td>5</td>
<td>2449858.79</td>
<td>8126.602</td>
<td>.000</td>
</tr>
<tr>
<td>GROUP</td>
<td>Grade%</td>
<td>235.430</td>
<td>8</td>
<td>235.430</td>
<td>.768</td>
<td>.381</td>
</tr>
<tr>
<td></td>
<td>Lab gr</td>
<td>269.819</td>
<td>1</td>
<td>269.819</td>
<td>.848</td>
<td>.357</td>
</tr>
<tr>
<td></td>
<td>HMWRK</td>
<td>79.944</td>
<td>1</td>
<td>79.944</td>
<td>.171</td>
<td>.679</td>
</tr>
<tr>
<td></td>
<td>Tst Ave</td>
<td>304.868</td>
<td>1</td>
<td>304.868</td>
<td>1.011</td>
<td>.315</td>
</tr>
<tr>
<td>GENDER</td>
<td>Grade%</td>
<td>6.077</td>
<td>1</td>
<td>6.077</td>
<td>.026</td>
<td>.871</td>
</tr>
<tr>
<td></td>
<td>Lab gr</td>
<td>1058.643</td>
<td>1</td>
<td>1058.643</td>
<td>3.328</td>
<td>.069</td>
</tr>
<tr>
<td></td>
<td>HMWRK</td>
<td>2566.369</td>
<td>1</td>
<td>2566.369</td>
<td>5.486</td>
<td>.020</td>
</tr>
<tr>
<td></td>
<td>Tst Ave</td>
<td>218.315</td>
<td>1</td>
<td>218.315</td>
<td>.724</td>
<td>.395</td>
</tr>
<tr>
<td>GROUP * GENDER</td>
<td>Grade%</td>
<td>1196.173</td>
<td>1</td>
<td>1196.173</td>
<td>3.903</td>
<td>.049</td>
</tr>
<tr>
<td></td>
<td>Lab gr</td>
<td>730.938</td>
<td>1</td>
<td>730.938</td>
<td>2.298</td>
<td>.130</td>
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<tr>
<td></td>
<td>HMWRK</td>
<td>2072.825</td>
<td>1</td>
<td>2072.825</td>
<td>4.431</td>
<td>.036</td>
</tr>
<tr>
<td></td>
<td>Tst Ave</td>
<td>961.797</td>
<td>1</td>
<td>961.797</td>
<td>3.190</td>
<td>.075</td>
</tr>
<tr>
<td>Error</td>
<td>Grade%</td>
<td>167019.259</td>
<td>545</td>
<td>306.457</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lab gr</td>
<td>173355.951</td>
<td>545</td>
<td>318.084</td>
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<tr>
<td></td>
<td>HMWRK</td>
<td>254937.931</td>
<td>545</td>
<td>467.776</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tst Ave</td>
<td>164296.596</td>
<td>545</td>
<td>301.462</td>
<td></td>
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</tr>
<tr>
<td>Total</td>
<td>Grade%</td>
<td>2925690.00</td>
<td>549</td>
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<td></td>
<td>Lab gr</td>
<td>3825247.77</td>
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</tr>
<tr>
<td></td>
<td>HMWRK</td>
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<td>549</td>
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</tr>
<tr>
<td></td>
<td>Tst Ave</td>
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<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>Grade%</td>
<td>168253.818</td>
<td>548</td>
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<td>Lab gr</td>
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</tr>
<tr>
<td></td>
<td>HMWRK</td>
<td>259915.269</td>
<td>548</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tst Ave</td>
<td>165490.209</td>
<td>548</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a R Squared = .007 (Adjusted R Squared = .002)
b R Squared = .012 (Adjusted R Squared = .006)
c R Squared = .019 (Adjusted R Squared = .014)
Further analysis of course grades (Table 10) shows that the distribution between groups was not significantly different, but that differences between groups exist.

Table 10: Chi Square Test of Grade Distribution

<table>
<thead>
<tr>
<th></th>
<th>GRADE</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Chi Square of Grade Distribution</th>
<th>Students Achieving A, B, C or D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>F</td>
<td>W</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Group</td>
<td>N=276</td>
<td>frequncy % within GROUP</td>
<td>41</td>
<td>14.9%</td>
<td>115</td>
<td>41.7%</td>
<td>49</td>
<td>17.8%</td>
<td>36</td>
</tr>
<tr>
<td>Non-treatment Group N=296</td>
<td>frequncy % within GROUP</td>
<td>46</td>
<td>15.5%</td>
<td>104</td>
<td>35.1%</td>
<td>68</td>
<td>23.0%</td>
<td>34</td>
<td>11.5%</td>
</tr>
<tr>
<td>Totals for class N=587</td>
<td>Count % within Group</td>
<td>90</td>
<td>15.3%</td>
<td>223</td>
<td>38.0%</td>
<td>119</td>
<td>20.3%</td>
<td>73</td>
<td>12.4%</td>
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</tbody>
</table>

Although the chi square test results presented in Table 10 show that patterns of grade distribution for the treatment and non-treatment groups were not significantly different, variation in course grades was notable as can be seen in Figures 3. The three comparisons with the greatest variance are most clearly shown in Figure 3: the treatment group had 6.5% more B grades and 5.2% fewer C grades than the non-treatment group, and 2.9% W grades to the non-treatment group's 5.4%. The next greatest difference was in D grades, in which the treatment group earned 1.5% more than the non-treatment group. The difference in numbers of A and F grades for the groups were within one percentage point. In addition, students in the treatment group achieved a greater number of passing grades, 87.4% compared to 85.1% for the non-treatment group. While these
data support use of the treatment, none are statistically significant and so could have occurred by chance alone.

Even though the mean score for each exam and students' mean course scores were the same for the two groups, it was important to consider the effects of homework grades on students' overall grades. An independent samples $t$-test showed that the mean homework scores of the treatment and non-treatment groups were also homogeneous with mean scores within one tenth of a point. However, a Pearson correlation test revealed a statistically significant relationship between gender and homework, ($N=564$, alpha= .05, $p = .013$), and further exploration confirmed significance, showing that men scored a full five points lower than women in mean homework scores across treatment and non-treatment groups ($t = 2.24$, df 562, $p = .025$).
T-tests isolated the effect of homework scores of each group (see Table 11), showing that gender differences were apparent both between and across groups with the main difference occurring within the non-treatment group. Note that the number of students in each group reflects those who did homework and turned it in for a grade, 97.1% of the students in the treatment group and 95.3% of the students in the non-treatment group. Table 9 shows that, despite homogeneity of homework means for groups as shown in the “Between Groups” row, women in the non-treatment group had the highest mean score in the class while men in that group had the lowest mean score for homework. In contrast, the mean scores of males and females in the treatment group were similar to each other and near to the class mean.

Differences in mean lab scores were less dramatic than differences in homework mean scores, but displayed an identical pattern (see Table 12). Women in the non-treatment group earned the highest mean score for labs, men in the same group had the lowest mean, and men and women in the treatment group had mean scores that were similar to each other and to the class mean. Also, women in both groups scored higher than men in their groups, resulting in a significant gender difference across groups. A final point of interest was that the greatest variability within a group occurred consistently among women in the treatment group. The low scores earned by the portion of women in the treatment group who completed the course with difficulty instead of withdrawing is reflected by the greater group variability. In contrast, women in the non-treatment group had the least variability in lab scores and the highest withdrawal rate.
### Table 11: Comparison of Mean Homework Scores by Group and Gender

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>df</th>
<th>( t )</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment M</td>
<td>M</td>
<td>180</td>
<td>75.63</td>
<td>20.59</td>
<td>1.53</td>
<td>266</td>
<td>-0.159</td>
<td>.874</td>
</tr>
<tr>
<td>F</td>
<td>88</td>
<td></td>
<td>76.08</td>
<td>24.99</td>
<td>2.66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-treatment M</td>
<td>M</td>
<td>168</td>
<td>72.34</td>
<td>21.32</td>
<td>1.64</td>
<td>280</td>
<td>-3.356</td>
<td>.001**</td>
</tr>
<tr>
<td>F</td>
<td>114</td>
<td></td>
<td>80.93</td>
<td>20.79</td>
<td>1.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment M</td>
<td>F</td>
<td>180</td>
<td>.75.63</td>
<td>20.59</td>
<td>1.53</td>
<td>346</td>
<td>-0.465</td>
<td>.144</td>
</tr>
<tr>
<td>Non-treat M</td>
<td>M</td>
<td>168</td>
<td>72.34</td>
<td>21.32</td>
<td>1.64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>114</td>
<td></td>
<td>80.93</td>
<td>20.79</td>
<td>1.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment F</td>
<td>M</td>
<td>88</td>
<td>76.08</td>
<td>25.00</td>
<td>2.66</td>
<td>200</td>
<td>-1.504</td>
<td>.134</td>
</tr>
<tr>
<td>F</td>
<td>114</td>
<td></td>
<td>80.93</td>
<td>20.79</td>
<td>1.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Across M</td>
<td>M</td>
<td>353</td>
<td>73.83</td>
<td>21.33</td>
<td>1.14</td>
<td>562</td>
<td>-2.240</td>
<td>.025*</td>
</tr>
<tr>
<td>Groups F</td>
<td>F</td>
<td>211</td>
<td>78.14</td>
<td>23.31</td>
<td>1.60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between M&amp;F</td>
<td>M &amp; F</td>
<td>268</td>
<td>75.78</td>
<td>22.09</td>
<td>1.35</td>
<td>548</td>
<td>-0.018</td>
<td>.986</td>
</tr>
<tr>
<td>Groups M&amp;F</td>
<td>F</td>
<td>282</td>
<td>75.81</td>
<td>21.49</td>
<td>1.28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at alpha .05; ** Significant at alpha .001.

In general, homework scores would be expected to have a positive correlation with test scores, and both homework and lab scores should have a positive correlation with course grades. This was found to be true. A Pearson correlation between homework scores and students' composite test scores for the treatment and non-treatment groups was .76, a two-tailed test significant at alpha .001 level (n=550). The relationship between students' homework and test scores was somewhat stronger for the treatment group than for the non-treatment, which were .79 (N=268) and .72 (N=282) respectively. A similar relationship was found between students' lab scores and course grades, .77 for the treatment group and .75 for the non-treatment group. The relationship between students' homework scores and course grade percentages were stronger yet, with Pearson correlation factors of .86 and .81. In each case, relationships were significant at the alpha .001 level and were somewhat stronger for students in the treatment group than the non-
treatment group. The positive correlation indicates that higher course grades were earned by students with higher homework and lab scores, and lower course grades by students with lower homework and lab scores. Since women’s mean homework and lab scores were higher than men’s in both groups, and positive correlations with test and course grades were found, t-tests were used to compare students’ mean test scores by group and gender (see Table 13). Women’s mean test scores were not higher than men’s but were statistically similar by gender and group. Women in the treatment group had the lowest mean score and again displayed the greatest variability.

Table 12: Mean Lab Scores by Group and Gender

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>df</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment M</td>
<td>M</td>
<td>180</td>
<td>80.84</td>
<td>17.46</td>
<td>1.30</td>
<td>266</td>
<td>-0.196</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>88</td>
<td>81.33</td>
<td>22.29</td>
<td>2.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-treatment M</td>
<td>M</td>
<td>167</td>
<td>79.90</td>
<td>17.36</td>
<td>1.34</td>
<td>279</td>
<td>-2.652</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>114</td>
<td>85.20</td>
<td>15.03</td>
<td>1.41</td>
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<tr>
<td>Treatment M</td>
<td>M</td>
<td>180</td>
<td>80.84</td>
<td>17.46</td>
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<td>345</td>
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<tr>
<td></td>
<td>F</td>
<td>88</td>
<td>81.33</td>
<td>22.29</td>
<td>2.38</td>
<td>200</td>
<td>-1.470</td>
</tr>
<tr>
<td>Non-treatment M</td>
<td>M</td>
<td>167</td>
<td>79.90</td>
<td>17.36</td>
<td>1.34</td>
<td></td>
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<tr>
<td></td>
<td>F</td>
<td>114</td>
<td>85.20</td>
<td>15.03</td>
<td>1.41</td>
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</tr>
<tr>
<td>Across Groups</td>
<td>M</td>
<td>352</td>
<td>80.23</td>
<td>17.80</td>
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<td>561</td>
<td>-2.246</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>211</td>
<td>83.75</td>
<td>18.26</td>
<td>1.26</td>
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</tr>
<tr>
<td>Between Groups</td>
<td>M&amp;F</td>
<td>268</td>
<td>81.00</td>
<td>19.14</td>
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<td>547</td>
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<tr>
<td></td>
<td>M&amp;F</td>
<td>281</td>
<td>82.05</td>
<td>16.63</td>
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*Significant at alpha .05.
Table 13: Mean Test Scores by Group and Gender*

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<tr>
<th>Group</th>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>df</th>
<th>t-Value</th>
<th>Significance (2-tailed)</th>
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<tr>
<td>Treatment</td>
<td>M</td>
<td>187</td>
<td>69.58</td>
<td>18.55</td>
<td>1.36</td>
<td>274</td>
<td>1.258</td>
<td>.209</td>
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<tr>
<td>Within Grp</td>
<td>F</td>
<td>89</td>
<td>66.48</td>
<td>20.32</td>
<td>2.15</td>
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<td></td>
<td></td>
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<tr>
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<td>M</td>
<td>174</td>
<td>68.66</td>
<td>17.25</td>
<td>1.31</td>
<td>294</td>
<td>-0.330</td>
<td>.741</td>
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<tr>
<td>Within Grp</td>
<td>F</td>
<td>122</td>
<td>69.33</td>
<td>17.09</td>
<td>1.55</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Treatment</td>
<td>M</td>
<td>187</td>
<td>69.58</td>
<td>18.55</td>
<td>1.36</td>
<td>359</td>
<td>0.486</td>
<td>.627</td>
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<tr>
<td>Non-treat</td>
<td>M</td>
<td>174</td>
<td>68.66</td>
<td>17.25</td>
<td>1.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>F</td>
<td>89</td>
<td>66.48</td>
<td>20.32</td>
<td>2.15</td>
<td>209</td>
<td>-1.105</td>
<td>.270</td>
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<tr>
<td>Non-treat</td>
<td>F</td>
<td>122</td>
<td>69.33</td>
<td>17.09</td>
<td>1.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Across Groups</td>
<td>M</td>
<td>361</td>
<td>69.14</td>
<td>17.92</td>
<td>0.94</td>
<td>570</td>
<td>0.642</td>
<td>.521</td>
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<tr>
<td>Groups</td>
<td>F</td>
<td>211</td>
<td>68.13</td>
<td>18.53</td>
<td>1.28</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>M&amp;F</td>
<td>276</td>
<td>68.58</td>
<td>19.16</td>
<td>1.15</td>
<td>570</td>
<td>-0.236</td>
<td>.814</td>
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<tr>
<td></td>
<td>M&amp;F</td>
<td>296</td>
<td>68.94</td>
<td>17.63</td>
<td>0.98</td>
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<td></td>
</tr>
</tbody>
</table>

* Test scores for each student represent an average of tests one through four plus a makeup test, minus the lowest score, plus the final exam, the calculation used by the course instructor.

Although differences in mean test scores were slight, the cumulative result of group and gender differences in homework, lab, and test scores resulted in different patterns of achievement. Figures 4 and 5 illustrate the cumulative effect represented through course grades. In both figures, the “total” column indicates the percentage of male and female students in the group. In Figure 4, the greatest deviation from the total column occurs in the “W” (withdrawal) column; in Figure 5, deviation is most apparent in the “F” column and an interesting pattern is displayed throughout. Figure 6 further isolates results, showing that males in the non-treatment group earned 9.65% fewer A & B grades, 6.16% more C & D grades, and 3.49% more F & W grades than students in the other groups. Men and women in the treatment group and women in the non-treatment group earned similar grades in the course.
Figure 4: Percentage of Grades in Treatment Group by Gender

![Figure 4: Percentage of Grades in Treatment Group by Gender](image)

Figure 5: Percentage of Grades in Non-Treatment Group by Gender

![Figure 5: Percentage of Grades in Non-Treatment Group by Gender](image)
Significant differences in course outcomes were found based on students’ year in college, but these were not related to treatment and non-treatment group membership. As can be seen in Figure 7, of undergraduate students, freshmen scored highest on all measures, followed by sophomores, juniors, and seniors. Post-baccalaureate students scored well on all measures, but exceptionally well on homework, while seniors showed the opposite trend. These results led to the suspicion that uneven distribution of students by major or year within the treatment and non-treatment groups may have contributed to the between-groups homework and lab effects. However, the treatment group, in which mean homework scores were close to the class mean and homogeneous across gender, had six post-baccalaureate students (3 male and 3 female) while the non-treatment group, in which mean homework scores were significantly different, had four (2 male and 2
female). The eleventh post-baccalaureate student was in group 3, the non-lab group, and was the only student of these eleven who scored below 90% in homework (74%). Of the 14 seniors, whose course mean was lowest, (10 male and four female), eight were enrolled in treatment group labs and six in non-treatment group labs with gender even between the two. Statistical comparisons indicated that students’ year in school did not skew group comparisons.

Figure 7: Students’ Mean Scores by Year in College

![Chart showing students' mean scores by year in college]

Students’ major area of study also showed differences unrelated to membership in the treatment or non-treatment group (see Table 14). Overall grade means for students in the treatment and non-treatment groups ranged from a low of 63.4% for health science majors (N=43), to a high of 70.5% for students majoring in chemistry, physics, or biology (N=151). Engineering majors represented the largest group of students (N=218) with a mean grade of 69.4%. Test scores were similar to overall grades, but homework scores, while highly homogeneous and statistically equivalent between groups, showed
an interesting trend: Students majoring in agriculture, the health sciences, and the College of Letters and Sciences (music, art, English, and Social Science majors) earned the highest mean scores for homework and labs, but lower mean scores for tests and overall grades. As expected from previous results, gender differences were also apparent, varying by as much as 11%, but were related to students’ year in school rather than membership in the treatment or non-treatment group.

Table 14: Students’ Mean Scores by Major for Tests, Homework, Labs, & Course Grades

<table>
<thead>
<tr>
<th>MAJOR</th>
<th>TEST AVERAGE</th>
<th>HOMEWORK</th>
<th>LAB</th>
<th>COURSE GRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>N</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Agriculture</td>
<td>64.01</td>
<td>61</td>
<td>16.85</td>
<td>77.22</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLS (music, art, English, N soc. science)</td>
<td>66.84</td>
<td>27</td>
<td>22.33</td>
<td>79.27</td>
</tr>
<tr>
<td>Engineering</td>
<td>70.00</td>
<td>218</td>
<td>22.33</td>
<td>75.50</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>218</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
<td>21.65</td>
</tr>
<tr>
<td>General Studies</td>
<td>69.56</td>
<td>72</td>
<td>17.21</td>
<td>74.19</td>
</tr>
<tr>
<td>N</td>
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<td>72</td>
<td></td>
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<tr>
<td>Health Sciences</td>
<td>64.28</td>
<td>43</td>
<td>17.60</td>
<td>76.41</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>70.15</td>
<td>151</td>
<td>18.90</td>
<td>75.70</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>151</td>
<td></td>
<td></td>
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<tr>
<td>SD</td>
<td></td>
<td>18.90</td>
<td></td>
<td>15.65</td>
</tr>
<tr>
<td>Total</td>
<td>68.77</td>
<td>572</td>
<td>18.14</td>
<td>75.79</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>572</td>
<td></td>
<td>18.14</td>
</tr>
</tbody>
</table>

A final consideration regarding group differences in homework scores stems from actual differences in treatment versus non-treatment group activities. While both groups were encouraged to work on their homework with other students, the treatment group was encouraged more strongly. Results gathered at three points in the semester show that
students in the treatment group worked with an average of 2.14 students per group while
students in the non-treatment group worked with an average of 1.14 per group,
statistically significant at a .05 alpha level (N=381, t = 9.153, df 379, p=.003).

In conclusion, no statistically significant differences were found across the
treatment and non-treatment groups on test means or mean final course calculations.
However, once gender was included, significant measures of learning outcomes were
found in the non-treatment group: Women earned significantly higher scores in
homework and labs while men earned 9.65% fewer A and B grades, 6.16% more C and D
grades, and 3.49% more F and W grades than women in their group or men and women
in the treatment group. The treatment appeared to offset gender differences among mid-
range students in that the treatment group earned 6.5% more B grades, 5.2% fewer C
grades, and a 2.3% higher pass rate than the non-treatment group. There was no apparent
increase in students' use of learning strategies or metacognitive awareness of them. These
differences between group outcomes led to the conclusion that there is a relationship
between homework structure and course outcomes.

Research Question 2

Are there significant differences in pretest-posttest scores between the treatment
group and the non-treatment group on measures of attitude and use of learning strategies?
The Learning and Study Strategies Inventory (LASSI) was administered to three labs for
the treatment group and three for the non-treatment group chosen through stratified
cluster sampling. LASSI instruments were administered to each of the six labs two times,
first as a pretest during their first lab for Chemistry 131 and again as a posttest during the
final lab of the semester. Seventy-seven students took the first inventory, but only 62 students successfully completed the inventory two times, as both a pre- and posttest. Of the fifteen students who did not complete the second inventory, five dropped the course and nine did not complete all or part of the inventory. Demographically, students surveyed represented the class as a whole but academically the students representing the non-treatment group earned grades lower than the class mean, with a significant difference at the alpha = 1.0 level (see Table 15). A further check of students’ mean grades and homework grades by lab section showed differences that were not significant due to the small number of students in each section. Moreover, there was no significant correlation of lab instructor with student outcomes.

Table 15: Mean Course Grade of Students Who Completed the LASSI by Group

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>df</th>
<th>t</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade%</td>
<td>1</td>
<td>36</td>
<td>70.78</td>
<td>13.400</td>
<td>75</td>
<td>1.75</td>
<td>.084</td>
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<tr>
<td></td>
<td>2</td>
<td>41</td>
<td>62.68</td>
<td>24.731</td>
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</tbody>
</table>

The LASSI contains ten measures that correlate but are independent of each other. Authors of the LASSI designed the instrument to present individual student’s scores in graphs that indicate students’ strengths and weaknesses and provide a comparison to national results. For individual students, composite scores are meaningless, but for purposes of comparison between the treatment and non-treatment groups, composites scores were calculated. In addition, dependent t-tests comparing within-groups pretest and posttest scores were calculated for each measure, as were independent t-tests for between-group measures. The most notable trend was a drop in pretest to posttest scores
that occurred in greater or lesser amounts for each measure for both groups, resulting in
significant dependent $t$-values at alpha = .001 for both groups (see Table 16). The overall
independent $t$-tests that compared composite scores for the two groups indicated that
mean scores were closely aligned and showed a mean drop of 1.45 points for the class
from pretest to posttest.

Variability was apparent between groups on three of the LASSI subscale
measures. The most notable of these was “concentration” in which treatment group
students reported only a slight drop in scores ($p = .918$) while the non-treatment group
reported a drop significant at alpha = .001, resulting in a p-value of .065 on the
independent $t$-test for posttests. The non-treatment group’s notably high pretest score on
“anxiety” produced a significant difference on the independent $t$-test for pretests at alpha
= .05. The third difference, “information processing” was slight. Since the non-treatment
student participating in the LASSI study were not representative of the group as a whole
in that they had lower course scores than the mean for their group, these scores may not
have been representative of the group. Consequently, given the minor differences
between the groups and lack of consistency in findings, the research failed to establish a
relationship between structured homework assignments and assimilation of learning
strategies.
Table 16: Mean Pretest & Posttest Scores of LASSI Subscales & Composite by Group

<table>
<thead>
<tr>
<th>LASSI Measures</th>
<th>Treatment Group</th>
<th>Non-treat Group</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Treatment</th>
<th>Non-treatment</th>
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<th>Posttest</th>
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<th>Non-treatment</th>
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<tbody>
<tr>
<td></td>
<td>N = 26 df = 25</td>
<td>N = 36 df = 35</td>
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<td></td>
<td>N = 62 df = 60</td>
<td>N = 62 df = 60</td>
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<tr>
<td>Pretest - Posttest</td>
<td>27.73 - 27.38</td>
<td>27.73 - 27.92</td>
<td>4.35 - 5.51</td>
<td>4.18 - 6.16</td>
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<td>27.38 - 27.92</td>
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</tr>
<tr>
<td>Pretest - Posttest</td>
<td>31.31 - 29.00</td>
<td>30.72 - 27.38</td>
<td>5.95 - 2.068</td>
<td>3.75 - 4.15</td>
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</tr>
<tr>
<td>Pretest - Posttest</td>
<td>32.69 - 29.58</td>
<td>32.53 - 30.92</td>
<td>6.85 - 2.534</td>
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<td>.918</td>
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* Significant at alpha .05; ** Significant at alpha .001.
The Instructor's Perspective: Research Question 3

Are the experimental strategies manageable from the instructor's perspective in terms of ease of use and cost? The third research question was investigated through a triangulation of qualitative data including the researcher's field journal, a formal interview of the instructor and two teaching assistants, and an informal focus group conducted at a TA meeting at the semester's end. The research project began in response to recognition that student assimilation of learning outcomes within college chemistry courses and similar challenging courses is below an optimal level. Concerns stem from the high rate of D, F, and W grades assigned each semester, the need to curve grades to achieve an acceptable pass/fail ratio, and students' difficulty in learning in subsequent courses. The professor involved in the research has taught the course for seven years and teaches the subsequent chemistry course. Prior to the semester, he expressed the concern that the degree of success students achieve in college chemistry often affects important choices that they make such as the college major and career they will pursue. However, he also expressed recognition of the difficulty of the material and understanding that some students would not learn sufficiently to support their aspirations.

Findings from the Field Journal. The process of assisting change within an existing course taught by a second party is a challenging collaborative endeavor. When the class is large and the constraints of a research experiment are added to the mix, layers of complexity emerge. Even with attention to communication, certain problems occurred. When the professor and I agreed to collaborate, we discussed several possible ways to add structured assignments that would encourage students to work collaboratively and
implement SGCP strategies, with plans to model desired behaviors and provide feedback. For modeling, for instance, we discussed how the professor might use his weekly evening review sessions that were open to all Chemistry 131 students to interact with students on homework, demonstrating how he would approach problem solving and study techniques while fielding questions about the homework. In addition, he would encourage the Wednesday/Friday TA’s to use the twenty minutes of lab time that had been set aside in previous semesters for homework quizzes for similar weekly modeling and feedback sessions. In Tuesday/Thursday labs, the same time period was to be used to answer students’ questions about homework, but without special attention to modeling. The professor leaned toward writing homework problems or compiling them from test banks with SGCP modifications, but also considered using assignments from the text or computerized assignments available from the text publisher. He intended to decide mid-summer and be prepared with the first month’s assignments when school began.

However, summer is also the time when he is not preoccupied with teaching and attends to research, writing, and service, so when classes began, the final decision was still pending and no assignments prepared. Additionally, I had hoped to work with teaching assistants, who were responsible for selecting which homework problems to grade and for grading, to discuss modeling and feedback for the treatment sections. However, when the fall semester began, certain components of the course setup and constraints of the lab prevented this from occurring. The pattern that emerged was less than ideal: the professor wrote homework problems, I added modifications for the treatment group, and homework was distributed in lecture and returned via collection boxes outside the lecture room. No one modeled the desired behaviors or provided feedback other than homework solutions.
which were available for reprinting in the Student Union Building. I was able to attend TA meetings on two occasions and to administer the LASSI during the first and last lab sessions. The professor was helpful throughout the planning and implementation of the research design. His enthusiasm and understanding of the SGCP strategies was thorough but also posed a minor research problem—the homework assignments he devised were often worded to elicit use of the treatment strategies, making it more difficult to modify questions for the treatment group. Nevertheless, his ease in acquiring this ability bodes well for instructor autonomy in structuring future assignments to elicit use of SGCP strategies.

Findings from the interview with the Instructor. In an interview conducted December 13, 2002, the course instructor was asked how implementing the research affected his teaching and the ability of students to learn over the semester. The Professor identified both pros and cons. On the positive side, he said that it promoted active learning, group work and students’ sense of responsibility for their own learning. The change from assigning problems from the book for which a solutions manual existed to assigning and grading alternative problems forced students to choose whether they would put in sufficient effort to succeed. It also promoted active learning within groups, although some students still procrastinated:

“And so some days before deadlines, the deadlines for submitting the homework, there was a fantastic activity down in the help center on the first floor, and it was really wonderful to see, a lot of learning going on. And I feel that in some ways, I really feel that the students this year know their stuff a bit better. I really feel it’s a difference because they have been forced to work actively on it... It was harder for them this year to drop out of that activity [of working problems]... This forced them to work quite a bit more and quite a bit more actively. And it also led to a lot of
good interactions between them and the various groups they got involved in. So that, I think, was very, very positive and I’d like to find a way of continuing that.”

For the Professor, the negative factors were the time and work involved in devising homework assignments and making up answer keys. The financial cost was within usual course constraints:

“The large negative for me was connected to the fact that I did not have an independent source of homework problems and so all homework problems had to be designed and set from scratch, as well as the answer keys. And interspersed with all the other activities that are required for this course, it was a little bit too much. It was a little bit too much work at times.”

He considered using questions from a test bank, but said that most test banks are primarily multiple choice, which would not fit the SGCP paradigm, and that textbook publishers would not be able to provide a sufficient selection of questions. When asked if teaching assistants could help write homework questions, he said that they would not be able to assist with that responsibility. When asked, “If learning improved, do you feel the gains were worth the extra effort?”

He laughed and replied, “Well, it was worth it for the students. I don’t know if it was worth it for me, because I don’t get too much out of it, except satisfaction. But no, I mean from my personal point of view, considering the other demands and expectations on me, I would not be willing to put that amount of work in again. I wish I could.”

However, satisfaction is important. On an earlier question, the Professor explained that over the years he had talked to many individual students so that he could modify his teaching to relate well to them and to be able to ground the teaching in material and understandings that they already had. Additionally, he again expressed concern for students who have difficulty learning course materials:
"The other challenging aspect of the course is that there are quite a few students, a fair percentage of students, who are not doing well or who are failing the course and so there are many students who have career goals, stranded more or less by this course. So they are stressed, and I often feel quite bad about that. But at the same time of course, there is no other way than to hold up the academic rigor. They have to learn a certain amount of material and in subsequent courses, in engineering, geology, hydrology, whatever it might be, they need this background information."

His conclusion: "I really like the assignments and forcing them to do their independent work, no doubt about it. And I feel that the group, the group work was also good. If there was no study going on, I would strongly encourage them...to work in groups... But as I said in an earlier question, I don’t think that I’m really able to do this again. The only way I could do it would be if I found a less labor-intensive way of putting together these assignments."

Findings from an informal meeting of Teaching Assistants. While waiting for a meeting to begin near the end of the term in November, 2002, several teaching assistants held an impromptu discussion from the question, "From your perspective as a TA, how did this semester’s homework assignments work out?" Their responses are included in their entirety:

"It takes a lot more time than last year—about two extra hours per week [to grade homework]. Last year we gave quizzes and I planned mine so they’d be easy to grade."

"Yeah, the quizzes were easier. The assignments aren’t bad, but the organization could have been better to make it easier to grade."

"The students don’t feel it’s worth their time either. They have to do all of those problems and only get graded on about 10 percent of what they’ve done."

"They’re learning more though. I don’t know if you can compare last spring with this fall—different teachers—but they definitely understand more about the homework and work harder at it."

"There weren’t enough problems though. They need to work a lot more problems to really understand what’s going on."
Findings from TA Interviews. Two teaching assistants volunteered to be interviewed about their perceptions of the fall chemistry course during finals week in December, 2002. Both were undergraduates, one male and one female. The following responses concern their role as a TA and the question of whether the experimental strategies were manageable from their perspective in terms of ease of use. Interestingly, both TA's took it upon themselves to spend about 20 minutes per lab providing background information that might help students to understand the concepts involved. Additionally, one TA said she felt that it was her job to help motivate students to learn chemistry:

"I feel it's not only my job to teach them, but to kind of try to make them like chemistry and that's a tough job. There seems to be a kind of overlying anxiety regarding general chemistry and even before they start class they hear rumors about how it's nasty and how half the people fail. They bring that in with them so kind of don't even try sometimes because they know no amount of work can get them an 'A.'"

When asked if she was trained in motivation, teaching, or how to be a TA, she said she was not, just in what each lab was about and the best way to present the material, but offered,

"It might be a good idea to look into writing some instruction to TA's about how to be good TA's, not just what to teach."

She noted that the semester in general went well, that she had fun and felt that her students didn’t hate chemistry anymore, and had actually learned. She said that her own chemistry course, taken at another university, had had more depth and rigor, and that the tests, which were not multiple choice, were more difficult. For the question, "The research itself caused some changes in homework protocol this semester. Can you explain from your perspective how it affected your teaching and student learning?" she answered:
"I'd say that it was a very good idea on somebody's part. When they got to lab, they knew what was going on in terms of the lab that day. At least as far as the lab actually followed the homework, which was, you know, not the best at times. That made them learn it before the night before the final. That was good."

She surmised that some labs were assigned early in the semester because they required minimal lab skills rather than to coincide with lecture materials and said,

"A lot of times students got to the lab and they had no idea about the equations or theories that were being discussed or taught in the lab. So basically it was up to me to provide some kind of background, which is a lot to ask I think, because I wasn't prepared either... They kind of put us in the position of having to be a professor at times. And if I'm the first person from whom they hear this material, I could provide a lot of impact on the labs or else I could really screw them up. So I didn't like that kind of pressure."

In addition to overseeing sections of lab, TA's also staff the Chemistry Help Center, a small room with several tables and computers. When asked how that went this semester, she said, "That's chaotic at times," explaining that two dozen students might be seeking help from "some poor frazzled TA" prior to Wednesday deadlines for homework. Then she added that she'd had a great experience helping six students from her Thursday lab with the final homework assignment. She explained that she was reading a definition to a student from the book,

"and they were like all glazed over and one of the girls got up there and was giving all these demonstrations of what these molecules were doing and they were like, 'oh, cool,' and I felt like the homework was really good in terms of helping people to talk about the concepts behind things and like having students explain to other students... So that was really fun to see them teaching each other stuff and having it click."

The next question asked if the professor used similar assignments in future semesters, could she suggest a way to make it less work-intensive. The TA answered that she did not feel it was work-intensive, but was concerned that only three to five questions were graded on each assignment and that students might not know if they got others
wrong. Question: Did you know there was an answer key to the homework in Cards ‘n Copies every week? Answer: No.

The second TA had Wednesday labs and was on his third semester as a TA. He felt that students were more organized this semester in comparison to previous semesters, but did not attribute that to anything in particular. He also said that in previous semesters certain students would not do homework problems and so would perform badly on quizzes. This semester he felt similar students would perhaps do half an assignment but get more points depending on which problems were graded. However, he added that the homework might have helped and that the assignments helped students to be aware of which chapter they should be on.

“I’ve seen in past semesters, some of the poorer students will just kind of lose it for a couple of weeks and then they won’t even know what chapter they’re supposed to be on. I think if anything, that was good.... One thing I did notice about my classes was that I didn’t have—normally you get several drops at the end of the semester and I didn’t see that this semester. And again, I don’t know if that had any relevance.”

Question: “Restructuring assignments was also intended to shift responsibility for student learning toward the students by causing them to use learning strategies such as summarizing important points, clarifying their understanding, generating questions, predicting, and visualizing. Do you think that happened?” Answer:

“Well, definitely generating questions. As far as predicting and visualizing, I would say no more than in previous semesters. And, obviously if they did it, I’m sure it helped their understanding somewhat.”

However, the TA went on to explain that he felt the students need to do more problems, assigned and unassigned, to learn course content. He cited one student whom he advised to study more to improve her grades and said that she tried it and gained
twenty points on the next exam. He also noted that some students’ math and calculator
skills were not adequate for chemistry and that the computers in the labs required
learning time that would be better spent on chemistry skills such as calibration. In regards
to ease of use, this TA felt there were two problems. One was that the assignments took
more time to grade than the quizzes of previous semesters. The second was
administrative in that grading sheets might not be available until just before results were
due.

In their role as teaching assistants, the two undergraduate interviewees were able
to provide insight into student and instructor concerns. It was evident that both were
invested in the success of their students and encouraged them to find successful ways to
learn. One promoted more time on task and the other sought to make learning chemistry
fun and less stressful. Both also spent lab time going over concepts, yet these instructors’
students earned average grades for the class, suggesting that either lab instruction did not
impact grades or that their instruction was average. The concern about students’
inadequate calculator skills was interesting in that the instructor also identified it as a
serious milestone for some students. In addition to general learning strategies, learning
chemistry requires specific skills and timely application of effort.

The Students’ Perspective: Research Question 4

Do students gain in understanding of learning strategies by completing course
assignments that are structured to encourage their use? The fourth research question was
also addressed through qualitative means, including focus groups interviews of students
and telephone interviews. Three focus groups interviewing a total of 12 students were
conducted during final lab meetings and were taped and transcribed. Individual telephone
interviews were conducted early in the following semester and were not taped. The
research question was approached in parts to determine if students felt that they learned
course concepts, what they felt contributed to or interfered with learning, if they were
aware of and used learning strategies, and what they would suggest to improve learning
in the course.

The research findings suggest that students do not gain in understanding of
learning strategies merely by completing assignments in which they use strategic
techniques such as summarizing, predicting, clarifying, and questioning. Findings in
previous research (Annis, 1983; Bruner, 1986; Durrance, 1998; Gruber, 1962; Heiman,
1987; Keimig, 1983) document that students’ explicit understanding of learning strategies
assists them in learning how to use strategies and also develops their ability to provide
metacognitive oversight for their own learning. Vygotsky, Bandura, Seligman, and others
have equally compelling research that shows “doing” can proceed “knowing” and that
people learn vicariously through observation when they attend to it. Ideally, the use of
learning strategies would have been modeled for students in labs and at the Chemistry
Help Center, which would have helped to make the existence and use of strategies salient
for students. Findings from Supplemental Instruction suggest that students continue to
benefit from SI sessions through the semester following the course in which they
participated. At the time of this writing, the consistency of students’ LASSI results and
interviews indicate that no understanding of learning strategies occurred as a result of the
experimental treatment, but again, further research is indicated.
In regards to whether students felt that they learned course concepts, answers ranged widely. One student claimed to understand 75% of the material and feel comfortable with 76% of it, while in a focus group the reply, “I don’t think the material was understandable. I don’t know what exactly I was supposed to learn from the course” was seconded. A third student elaborated, “I’m not really sure what it was we’re actually supposed to take away unless it was the details about atoms and such. But as far as the overall picture of how it all fit in, it’s a little blurry.” A group of six students agreed that they understood the concepts taught in labs while those from lecture were more vague and confusing. Most students seemed to feel there was not a strong connection between the lab and lecture portions of the course, but that they had learned adequately in both areas. One student remarked, “I thought it went fairly well. I got an A. It was fairly hard but not impossible; about what I expected.” Another said, “I failed it and am taking it again this semester. I did learn quite a bit, and some of my test scores were okay, but I failed the lab so that brought me down.”

When asked what contributed to learning, the number one answer was homework as it provides practice, forces students to go through the steps necessary to get answers, is strongly related to test questions, and, as one student put it, “is due.” The second most common answer was doing labs, with hands-on practice that grounds theory and small-group interaction to promote learning. One student said that although he hated doing it, writing lab reports forced him to learn course concepts. The third most cited way to learn was to attend the professor’s weekly review sessions. Other factors that received honorable mention were previous chemistry courses, the CD-rom that was included with the text, and the text, lecture and tests. Working in small groups received praise to
criticism five to one and was mentioned in conjunction with homework, labs, review sessions, and the Chemistry Help Center. The Help Center, however, was criticized five to one. While many students said they used it, the general consensus was that the Help Center had too many people and not enough room, and that the TA on duty was often unable to answer questions adequately, sometimes causing more confusion than clarification, or that different TA’s provide different answers to the same question. One student commented, “The math help department is twenty times more helpful than the chemistry one. I go to both of them regularly and I actually come away from the math center feeling like I got helped and in chemistry I just feel more confused.”

On working on homework in groups, a typical comment was: “It went really well. It’s good to pool knowledge and not look everything up in the book, but to share ideas among students. I thought that worked well.” One student said, “Sometimes I did it on my own. I like to work it out myself, to be sure I learned it. It’s easier in a group.” Another noted that he did the homework with his roommate: “I think it helped him more than me. He explained a lot of stuff to me and it helped me to understand, but he got the A. It would have helped me more if I could have done more of the explaining.” One student noted that it was “kind of a pain” to do homework in a group and several said they preferred to work alone. A group of two women and a minority man agreed that working in a group was “nice.” As one put it,

“For me, it was just studying with other people that seemed to understand it a little better than I did. They would be able to explain it in a way, I think, because there’s different ways of learning, and I’m not very good at math or anything and so I need someone to really kind of spell it out, well, this is what this means, this is the why of it, as opposed to just, this is how it is—just do it.”
While many students did not feel anything interfered with their learning, others cited confusion and frustration as primary concerns. Nine students in two focus groups deplored the lack of feedback on homework and said they were not aware that answer keys were available for purchase. Two students mentioned a concern about unfair grading within labs in that lab reports were not required in all sections. The large size of the lecture class and the occasional failure of the microphone also received mention.

Students’ answers were most united in their overall lack of knowledge about learning strategies. Primarily, students seemed to equate the time spent studying with the terms study skills and study strategies. The following exchange was typical:

Question: “Do you feel that your study skills changed over the semester?”

Answer: “Not last semester, but they’re getting better now. I didn’t really study enough. I went to class every day and read over my notes before tests, but not much more.”

Question: “Can you explain how they’ve changed?”

Answer: “This semester I do a lot more studying.”

The most common answer, however, was that their study skills had not changed, and two students said theirs had regressed due to frustration. By that, they meant they had quit attending lecture.

On a related topic, students were asked if they used the study tips embedded in the textbook. Most students said they did not notice or read the tips. Only one student said she had read and used them, commenting “I did everything I thought would help.” The same student was fourth in the following focus group exchange:

Question: “The first homework assignment included study tips specifically geared toward chemistry. Did you find those useful?”
Answer 1: “I never read them.”

Answer 2: “Me neither.”

Answer 3: “I read them, but that was about it.”

Answer 4: “I read them and used them. It really helped to read over parts of the chapter before the lectures—that way I understood what the instructor was talking about.”

Other comments were:

“No, I didn’t use those. I have my own way of doing things that works for me.”

“For the first few weeks and then I forgot to use them.”

“I don’t even remember what they were or if I read them.”

The final question asked students what they would suggest to improve learning in the course. Suggestions included reducing the size of the lecture, increasing the size of the Help Center and selecting more experienced staff, and the following comment:

“The homework and the lab are my best grades and the test from lecture is where I bombed the course. So I don’t know, if what we apply in lab and the homework isn’t relevant enough to pass on the test, then I guess my suggestion would be to put more emphasis on what’s really important. Because obviously it’s important enough that they’re testing us on it.”

The students who took part in focus groups and telephone interviews expressed sincere interest in responding to questions and explaining their experiences with the chemistry course. In some cases like the final quote above, students were motivated to try and puzzle out why their efforts had or had not been successful in attaining suitable grades. In separate interviews, three entering freshmen said that they had liked chemistry in high school and had gotten good grades and wondered why they were unable to perform better in the college chemistry course. The size of the class and difficulty in getting questions correctly answered were also points of concern. The confusion these
students expressed and their efforts to learn in a way that would be adequate for college suggested they were motivated and desired to persist, but lacked training in self-directed learning. Students whose efforts had been successful were less interested in discussing the course and initiated fewer comments. As one student said, “It was about what I expected.” In a way, knowing what to expect is at the heart of learning. Most comments, however, were made by students who hadn’t known what to expect and did not expect to know next time, either.

Conclusions

On the first research question, the primary area in the findings that indicates significant between-groups differences in learning outcomes between the treatment and non-treatment groups involved gender differences. Significantly fewer women initially enrolled in Chemistry 131 than men, 37.5% to 62.5%, and their performance within the class varied from that of their male counterparts. Women’s homework scores were a significant eight points higher than men’s in the non-treatment group, and were also somewhat higher in the treatment group, resulting in a significant difference across groups. Women also achieved significantly higher across-group scores on lab grades with the highest scores occurring in the non-treatment group. Together, higher homework and lab scores equalized non-treatment-group women’s overall mean score with those of the men, counteracting women’s test scores which were statistically equal to but somewhat lower than men’s (particularly noticeable on final exam scores).

In the non-treatment group, males and females earned distinctly different patterns of grades (see Figure 6), in which as grades dropped, women were more likely to withdraw
from the course than men. In the treatment group, gender differences were less apparent except that only one woman withdrew, or 1.1% of the women in her group, compared to seven men, or 3.7% of the men in the group. In the non-treatment, eight women and eight men withdrew or 6.5% of the women and 4.6% of the men. The third, non-lab group also showed definite gender differences, including a higher percentage of women in the group (53.3%), all of whom were either repeating Chemistry 131 or who had taken Chemistry 121, which was not a prerequisite course, or both.

Together, it appears that women applied a different strategy to the course, enrolled at a lower rate, worked harder at homework and labs, took pre-enrollment preparatory measures (as seen in the non-lab group), and had a higher tendency to withdraw from the course (as occurred in the non-treatment group). However, treatment group results indicate that students who used structured assignments did not experience similar gender-related discrepancies in course outcomes. Instead, for the treatment group, women’s homework, lab, test, and course grades were comparable to men within the same group, except that women showed a reduced tendency to withdraw. Similarly, the men in the treatment group did not tend to earn lower homework and lab scores than women with the result that an equivalent percentage of males and females earned A, B, and C grades in the treatment group, while a significantly lower percentage of men in the non-treatment group earned A or B grades. These findings are in agreement with previous SI findings that while “A” students may be unaffected by SI assistance, mid-range participants experience greater support from collaborative learning and use of study strategies. In considering gender differences, the higher homework scores men in the
treatment group earned in comparison to men in the non-treatment group may result from working with women, working in groups, or from similar perceptions of support.

On the second research question, no significant between-group differences were found in measures of attitude and use of learning strategies as a result of the treatment. A small difference in levels of anxiety found in that the non-treatment group indicated less initial anxiety and lower posttest scores on concentration, but these may correlate more strongly with their significantly lower course scores than with group membership. The posttest scores across the ten measures were lower than pretest scores, causing a significant across-groups difference. The drop brought scores in line with national averages for college students and probably reflected students' adjustment from high school to college-level academics. The lack of differences between groups indicates that students in the treatment group did not consciously or knowingly assimilate positive learning skills, strategies, or attitudes from the more highly structured homework assignments.

The third research question investigated whether the costs and use of structured assignments was manageable from the instructor's perspective. The intention behind grounding Supplemental Instruction techniques in course assignments was twofold: to reduce financial expenses and administrative effort associated with institutional use of SI while maintaining some or all of the benefits for students. At the time of the interview, the instructor did not know if students benefited from the experimental project; therefore, his responses were based on his own experiences of planning, implementing, and assessing the structured assignments.
In regards to financial aspects, the cost of using structured assignments was within usual budget constraints for the department and students. During the research semester, the department photocopied approximately one page per week per student. For their part, students who were aware that answer keys for homework were available may have purchased keys for approximately 20¢ per week. In contrast, the cost of providing SI support for a chemistry course at the University of Missouri-Kansas City during the same semester, including training, administration, payroll, and photocopying, was $2000 for 30 students served per SI session.

Aside from initial guidance in developing SI techniques for individual courses and educating instructors in regards to SGCP strategies, all administration of structured assignments falls to the course instructor. Therefore, the issue of ease of use was of primary interest. In his assessment of the semester’s experience, the instructor involved in the study concluded that while he liked using structured assignments and felt that students learned better from them, the level of work involved would likely prevent him from using them in future. In reaching this conclusion, the professor assumed that he would have to construct weekly course assignments through one of various options, modify them to promote SGCP use, create answer sets, and oversee assessment. In actuality, many less work-intensive options exist, some of which were rejected for use during the research due to their lack of fit with the experimental design. These will be explored further in Chapter 5. The instructor’s early appreciation of the SI paradigm, and his ability to construct assignments that promote SGCP strategies in students’ work, indicate that little training may be required in assisting instructors in initial administration of structured assignments. However, ongoing support in choosing and modifying
assignments would likely assist with successful autonomous administration of SI-like assignments.

The responses of teaching assistants regarding the manageability of the structured assignments varied to some extent. No untoward difficulties were reported: the only research-related concern was the potential for increased time requirements to grade assignments. Reduced-effort grading options will be discussed in Chapter 5 with alternative methods of structuring assignments for ease of use.

The fourth research question was based on the premise that ideally, students would not only be led to use effective learning strategies, but would gain a metacognitive understanding of how they learn and how to transfer learning skills to new situations. Initial assessment of the research does not indicate that students gained significant knowledge of strategies or awareness of them. In SI research, learning about learning and transfer of learning has been assessed through follow-up studies of students’ college retention patterns and performance in subsequent semesters. These go beyond the constraints of the current research project, but are indicated for future study.

In the current study, no modeling of group interactions or SGCP-type responses occurred in class, and students received no oral feedback on homework; therefore their only exposure to learning strategies came through reading the homework assignments and working alone or in groups. Qualitative responses to interview questions indicated that most of the chemistry students read to locate information rather than read to assimilate: the majority indicated that they did not read study tips embedded in their text and homework assignments. It seems unlikely that significant assimilation of learning
strategies occurred in the treatment group beyond that which occurred in the class as a whole.

Weaknesses and Inconsistencies in the Data

An inconsistency in the data involves the apparent discrepancy between students' homework, lab, course, and test grades. For instance, men in the non-treatment group had low homework, lab, and course grades compared to other students in the course, but had test grades that were statistically equivalent to other students in the course. Women in the non-treatment group experienced the opposite trend by earning high homework and lab scores but test grades that were statistically equivalent to other groups with the result that their course grades were equivalent to all students except men in their own group who scored lowest of all. This topic invites further scrutiny.

The quantitative portion of the data that evaluated between-group differences was consistent but weak and therefore lacked statistical significance in several areas. These include the following:

1. A greater percentage of students who were assigned the more highly structured homework passed the course (87.4%) compared to the non-treatment group (85.1%);
2. 97.1% of the students in the treatment group did their homework compared to 95.3% of the students in the non-treatment group;
3. Grades were skewed so that 6.6% more students in the treatment group achieved B grades and 5.2% fewer students earned C grades than students in the non-treatment group;
4. The percentage of students earning A's, D's, and F's were equivalent, but fewer students in the treatment group withdrew from the course-2.9% versus 5.4% for the non-treatment.

5. Students in the treatment group are thought to have used study strategies by following the prescriptions in their homework assignments, but did not gain in awareness of them.

Together, these differences indicate greater success for students in the treatment group, but are inconclusive. The lower withdrawal rate and increased success for mid-range students (more B's and fewer C's) agree with previous findings in studies using Supplemental Instruction techniques at the college level. In explaining SI results, Deanna Martin noted that participants' midrange grades tend to improve one half to one letter grade and that some students who might have otherwise withdrawn from highly challenging courses stay enrolled due to the support the SI component provides. Since non-withdrawing students tend to earn low grades, their continued enrollment masks achievement differences between SI and non-SI students. In the current case, if students in the treatment group had withdrawn at the same rate as those in the non-treatment group, 12 fewer students would have completed the course. In itself, course completion does not equate with passing grades, however, the higher pass rate of the treatment group (2.3% higher than the non-treatment) indicates that many did. Traditional SI assesses its success on the percentage of students who achieve A, B, and C grades compared to non-SI students; the between-group difference in these was very slight, with achievement by the treatment group at 74.4% and non-treatment group at 73.6%; however, traditional SI
is used only with students who volunteer to participate, so has potential selection bias that might exaggerate its effectiveness.

Possible causes for weakness in the data are contamination of SGCP-inducing questions to non-treatment group homework as noted in the field notes, lack of modeling of group interaction to promote use of learning strategies, and lack of feedback to students on homework results.

Summary of Results

The research was designed to investigate whether Supplemental Instruction techniques could be embedded in course assignments in order to improve student learning in a cost-effective and manageable way. Some portions of the research were inconclusive while others supported the use of the specially structured assignments. For one, results showed that the structured homework assignments were successful in encouraging students to work on assignments in groups. Improvements in mid-range grades of the treatment group and the percentage of students staying enrolled and passing the course were statistically marginal. However, interesting results were found that involved previously unrecognized gender differences displayed by the non-treatment group. These differences, that included significantly low mean scores for men on homework and labs, and lower mean course grades, and a higher rate of withdrawal among women, were significantly absent in the treatment group, indicating that gender-based differences were less likely to occur with use of structured assignments.

The course instructor expressed satisfaction with students’ learning and level of engagement with course assignments, but dissatisfaction with the time and effort he
expended to support the structured assignments and the research. He noted that if he could achieve similar results in a less labor-intensive manner, he would be interested in continuing to structure assignments and have students work on them in groups. There was no evidence that students’ attitude toward, or future use of learning strategies was affected by the treatment.
CONCLUSIONS

Educational curriculum develops in response to what is to be taught, how it will be taught, and who will learn (deMarrais & LeCompte, 1999). The content of courses such as college chemistry is intentionally integrated with students' preparatory learning, their ability to assimilate, and their need to know. However, the educational preparation of students entering college—including their understanding of how to direct their own learning—can vary widely, complicating the delivery and attainment of desirable learning outcomes (Muraskin, 1999). At the college level, an educational intervention that has been successful in helping students to bridge discrepancies in learning in challenging courses is Supplemental Instruction. Supplemental Instruction (SI) was developed by Deanna Martin at the University of Missouri-Kansas City in 1973 and uses peer-led study sessions to encourage students to apply the learning strategies of summarizing, questioning, clarifying, and predicting (SGCP) to course materials. The program is used at institutions of higher learning world wide and is endorsed by the U.S. Department of Education, but is costly and administratively complex, requiring coordination, training, and oversight for each target course. An additional drawback of SI is that only students who have the time and motivation to voluntarily attend sessions may benefit from it. The current research was undertaken as a potential alternative to SI in which course assignments for all students were structured to elicit the use of the SGCP learning strategies while accomplishing the following:
1. Students were to be encouraged to use the effective learning strategies of questioning, summarizing, clarifying, and predicting in a social learning context.

2. The instructor would retain the locus of control over the content of learning materials, but would not be burdened with complex, costly, or time-consuming preparations.

3. Rather than replacing course components, the learning materials would be supplemental, complementary, and designed to assist students in learning required material and in assimilating effective learning strategies.

Together, these considerations framed a potential solution to the research problem, that college instructors of challenging entry-level courses do not have manageable, effective ways to induce students to use learning strategies that are proven to promote learning.

The purpose of the quasi-experimental study was to investigate structured course assignments versus unstructured assignments in relation to measures of learning outcomes and students’ assimilation of learning strategies. In addition, the study provided a format for qualitative investigation of the manageability of structured course assignments from the instructors’ perspective regarding ease of use and cost, and students’ attitude towards and use of learning strategies. The four research questions investigated were:

1. Are there significant differences in measures of students’ learning outcomes between the treatment group in which homework assignments were structured to induce use of learning strategies and those of the untreated group whose homework assignments were not specially structured?
2. Are there significant differences in pretest-posttest scores between the treatment group and the non-treatment group on measures of attitude and use of learning strategies?

3. Are the experimental strategies manageable from the instructor's perspective in terms of ease of use and cost?

4. Do students gain in understanding of learning strategies by completing course assignments that are structured to encourage their use?

The approach used to conduct the study had four components, one to measure each of the research questions. The first measured experimental results in terms of course outcomes, the second measured assimilation of study strategies through pretest-posttest inventories, the third investigated instructors’ perceptions of cost and time effectiveness primarily through interview, and the fourth used focus groups and interviews to investigate students’ perceptions of changes in their use of study strategies.

Statistically significant differences in course outcomes between the test and control groups were primarily gender related, indicating that while men and women earned statistically equivalent grades on tests in both groups other differences were evident. For one, men and women in the control group had statistically different scores on homework and in labs, with women scoring higher on both. Additionally, women earned proportionally more A and B grades than men, and consecutively fewer C, D, and F grades but an equal number of withdrawals. In the test group, gender differences did not exist with men and women having equivalent scores on homework and labs, and men earning comparable grades to women in their group. The exception was that half as many
students in the treatment group withdrew as in the control group and only one of the eight withdrawing students was a woman. Students in the test group reported working on their homework in statistically larger groups, averaging 2.14 students per group to the control’s 1.14, and corroborated the validity of their reporting in interviews following the semester’s conclusion. No between-group differences were detected regarding assimilation of study skills, although across groups a statistically significant drop in study skills scores was noted. In itself, the drop was not of interest for two reasons. First, the two groups scored similarly and therefore did not show between-group differences. Second, the pretest represented the expectations of freshmen students regarding the efficacy of their study skills while the posttest represented the reality of more experienced college students. Qualitative interviews with students supported these findings.

Discussion of Broader Implications

The research findings lend themselves to interpretation in four general areas. The first area involves homework and raises issues such as: What factors affect the degree to which college-level homework assignments contribute to learning? Who learns from assignments? How do instructors determine how to structure homework assignments, and how do they determine what value to place on them? The second area is study strategies, leading to the questions, how and when do students learn how to learn and how to monitor their learning, and how can the structure of homework assignments affect assimilation of learning strategies? The third area is gender, raising the question, in regards to gender, how does the structure of a college-level science course affect who
takes it and the degree of success they experience within it? The final area involves the research itself: What factors affects the implementation of an experimental research design in an educational setting in which the researcher is not the instructor? Insight into the first two areas, homework and learning strategies, were an intended function of the research; the third was raised by research findings, and the fourth resulted from difficulties encountered. Each are discussed below.

Homework

Both the review of the literature and the findings from the current research suggest that the assignment of homework at the college level is unsystematic in that the following factors are typically reflected in its assignment and use:

1. College-level instructors are autonomous in deviseing course requirements.
2. Instructors receive little or no guidance in specific teaching skills such as how to devise effective homework assignments or grading policies.
3. Budgetary allowances may affect both instructors’ and students’ decisions regarding the purchase and use of teaching and learning materials.
4. Practical considerations such as the amount of time and effort instructors must expend in making assignments, communicating with students regarding assignments, and in grading them affects their decisions of whether to assign homework, what kind of assignment to make, who will grade it, and how they will provide feedback to students. These choices in turn affect students’ opportunities to engage in learning activities and their response to homework assignments.
5. Student learning at the college level tends to be more reliant on self-direction than in preparatory schools. In some courses, student grades are based solely on exam scores, and readings and learning activities may be perceived to be recommended rather than assigned and therefore optional.

In the Chemistry 131 course, the instructor considered numerous homework and grading options, some of which were based on services offered by the textbook publisher, such as computerized mastery tests. In choosing to assign and grade written homework, he considered factors that included:

1. Student learning: The concepts and materials included in the general chemistry course involve high-level thinking skills and underlying mathematical abilities. Assignments were devised to provide students with an opportunity to identify what they needed to learn and to practice skills.

2. Instructor convenience: The processes of assigning, collecting, and grading homework and of providing feedback to students had to be manageable for a large class (initially over 600 students) with two lecture and multiple lab sections.

3. Student convenience: The general chemistry course at MSU-Bozeman is a four-credit course that includes three 50-minute lectures and a three-hour lab each week—a greater time commitment per credit than is usual. In addition, students are given assignments in both labs and lecture, including reading 12 chapters of chemistry text and submitting lab reports. In devising homework assignments that complement learning of lecture-related materials, the instructor considered students' prior time commitments to the course, and his perceived need to avoid overwhelming students
with materials. Therefore, he assigned problems that seemed most important, relevant, and necessary, and omitted those he deemed of lesser importance.

4. Ethical considerations: The instructor actively sought to avoid assignment and grading policies that facilitated or rewarded cheating among students. In previous semesters, instead of collecting homework, he gave in-lab quizzes on random problems from those assigned. During the current semester, he devised assignments from a variety of sources to reduce the ability of some students to use solution manuals.

Students also provided insight into factors that affected their learning from homework:

1. Homework assignments were likely to be related to test questions and therefore provided an affirmation of which portion of learning materials are most relevant and important to learn.

2. Homework in courses such as chemistry provides practice in going through the steps in problem solving.

3. Homework provides intermediate due dates that help to keep students on track in regards to learning of course materials.

4. Ideally, homework helps students to make sense of what they are learning, form connections between various components such as concepts, formulas, skills, and previous learning, and to understand “how it all fits in” and “the why of it.”

5. Social interaction of the sort that takes place in study groups tends to deepen students’ efforts to make sense of materials, the regularity with which they apply effort, and their efficacy regarding learning.
Continuing confusion interferes with learning and students' sense of efficacy regarding learning; help centers or help sessions, group work on homework, and timely feedback lessen confusion and contribute to students' ability to persist.

The opportunity to apply homework efforts towards a course grade allows students a sense of control, and contributes to greater efficacy and improved outcomes for those who use the opportunity.

These various perspectives regarding homework suggest that instructors and students rely heavily on prior experience in making decisions regarding their approach to homework. However, students indicated that they also react to the constraints of each course, seeking cues to better performance. This attention extends to the affective domain where students are susceptible to influence. In the course under study, results indicate that homework structured to encourage group work and use of study skills did influence students' reactions in that:

1. More men in the treatment group chose to do their homework than in the non-treatment group;

2. Men and women in the treatment group earned average grades on their homework and labs, but earned more A and B grades and passed at a higher rate than men in the non-treatment group;

3. The treatment appeared to lend support to participants so that men in the treatment group succeeded at a higher rate than those in the non-treatment group while women persisted at a higher rate than women in the non-treatment group.
Study Skills

The research findings shed little illumination on students’ acquisition and use of study skills, nor was there evidence that the structured assignments contributed to assimilation of skills or metacognitive awareness of them. Students in the treatment group earned mean homework grades that were within .03 points of the mean grade of students in the non-treatment group, even though they were given longer and more complex assignments and were encouraged to work in groups. These students used study strategies in that their homework required them to summarize, define, extrapolate, predict, generate questions, provide examples, and discuss. However, the lack of explicit instruction in study skills allowed students to use them without attending to the use—an important requirement in learning. Previous research has shown that the best assimilation of study skills occurs when students learn to use them in the context of a challenging but manageable learning situation and when their use is made explicitly apparent to learners (Bandura, 1997; Dimon, 1988; Keimig, 1983; Vygotsky, trans. 1978). In the current research, only students who completed the pretest and posttest LASSI instruments were provided feedback on the use of learning skills, and that feedback was given following the conclusion of the study (see Appendix D). Neither quantitative nor qualitative research results answer the questions, how and when do students learn how to learn and how to monitor their learning, and how can the structure of homework assignments affect assimilation of learning strategies? However, these questions are clearly relevant and important and deserving of further study.
Gender

The subject of gender became part of the broader implications of the research as a result of demographic comparisons that showed gender effects existed in the control, or non-treatment group. That these effects were offset by the treatment, and that the makeup of the class as a whole was far more gender-biased than expected raised the question, how does the structure of a challenging college-level science course affect which students will enroll in it and the degree of success they experience within it? Despite significant results in this area, the current research cannot fully answer this question. The composition of the general chemistry class contained students from at least five groups:

1. Students whose major area of study required Chemistry 131: engineering, science, and particular options within agriculture and health sciences;
2. Students who were enrolled in General Studies or another major but who were considering one of the above areas of study;
3. Students who had previously taken the course and wished to improve their grade;
4. Students who planned post-graduate study in a chemistry-related field; and
5. Students who planned to use the course to fulfill a University core requirement for natural science.

Most of the participants, 559 of the 587 enrolled in the course, were from one of the first two groups in which general chemistry was a required course for their major, so it is then necessary to look beyond the current research and apply the question to these areas of study to ask, “How does the structure of a challenging science-based curriculum at the college-level affect which students enroll in it and the degree of success they experience within their major?” This question and those that are directed toward students'
preparatory experiences with science and math are related to the current study but go beyond its bounds. Given these limitations, the original question still invites scrutiny.

Results of the study indicate that the treatment—homework structured to encourage group work and the use of study skills—provided a crucial link in overcoming gender effects present in the untreated group of general chemistry students. This contention was based on a composite of the following information:

1. The initial enrollment of the entire class was 37.5% women and 62.5% men;
2. Of the 15 students in the non-lab group who were either repeating the course or who had taken Chemistry 121 before enrolling in 131 (not a pre-requisite), 53.3% were women and 46.6% men;
3. Six of the nine students (66.6%) in the non-lab group who took the precaution of taking Chemistry 121 prior to 131 were female;
4. Women in the non-treatment group earned significantly higher scores on homework than men in their group (80.93 and 72.33, respectively) while women and men in the treatment group earned scores that were proximate to the mean (76.08 and 75.63).
5. Women in the non-treatment group also scored significantly higher on labs than men in their group (85.2 and 79.9 respectively), while women and men in the treatment group scored similarly to each other and again close to the mean score (81.33 and 80.84).
6. For both homework and labs, women scored significantly higher than men within the non-treatment group and across groups.
7. In the treatment group, one woman, or 1.1% of the women in the group, withdrew compared to 3.7% of the men in the same group, and 6.5% of the women and 4.6% of the men in the non-treatment group.

8. In the treatment group, 87.5% of the women and 87.7% of the men passed the course; in the non-treatment group, an equivalent number of women, 87.7%, passed, but only 83.3% of the men passed.

9. In the treatment group, 56.8% of the women and 56.7% of the men earned an A or B grade; in the non-treatment group, an equivalent number of women, 56.6%, but only 46.6% of the men, earned an A or B.

10. The larger standard deviation among women in the treatment group on every measure, including test scores, homework, and labs, reflected students who persisted rather than dropping out of the course.

Together these findings indicate that women used a different approach to the course than, worked hard in the controllable grade areas of homework and labs, and dropped out earlier and at higher rates than men, but achieved higher grades than men, while men and women in the treatment group achieved at an equally high rate.

The Research

The final area of interest regarding broader implications involves the research methodology and the question, what factors affect the implementation of an experimental research design in an educational setting in which the researcher is not the instructor? Educational research is often initiated in response to a problem perceived by those directly involved in the educational process where the problem occurs. In these cases, the
course instructor has a vested interest in performing research to solve instruction-related problems and may be a primary investigator in the research. In Supplemental Instruction, change is typically initiated in courses where difficult content is combined with high expectations of autonomous learning. In these cases, the treatment is given outside of the classroom with volunteer participation by students and minimal instructor involvement in associated research or results. In each instance, the authority for the research lies with the person conducting the research.

In the current situation where the researcher had no previous connection with the course or authority to conduct research beyond permission of the instructor, a greater potential for problems existed. MSU's general chemistry course was chosen because it had a history of being a challenging course in which a high percentage of students failed or withdrew, but the SI-related intervention was non-voluntary for students and required instructor collaboration. Despite the instructor's involvement in deciding what the treatment would be and how to implement it, several obstacles resulted from the imperfect collaboration of effort between researcher and instructor, resulting in a diluted treatment and some inconclusive findings. Seven problems, several of which were successfully resolved during the current research, are identified and discussed below. While only one was of particular concern in this endeavor, all represent challenges in educational research of this kind.

First is a mutual lack of knowledge. Communication is always a challenging aspect of collaboration, but the situational realities of a large educational classroom exacerbated two types of problems that occurred. First, the instructor had an incomplete understanding of the theoretical basis for the research that implied appropriate
components of methodology, and second, the researcher had an incomplete understanding of the complexity of the course with its layers of organization and hierarchy of personnel. The failure to bridge these communication gaps led to a key error: The lab and TA coordinator was not consulted during the planning stages. By the time the mistake was realized, the twenty-minute window of weekly lab time that was to be allocated for reviewing homework and modeling use of study skills in the treatment sections had been scheduled for other purposes. In retrospect, it is easy to see how this happened. The instructor was concerned about his responsibility to co-construct and implement a manageable treatment that offered potential benefit to students without risking harm to either the treatment or non-treatment groups. Since the teaching assistants were not his responsibility, he paid little attention to the component of the research that involved their use. The researcher believed that the instructor’s responsibilities included oversight of TA’s and labs. To avoid gaps in communication, researchers should ask pertinent questions during the planning phase including:

1. What are the main components of the course and how do they fit together?
2. Who shares responsibility for the instructional components of this course and how does that work?
3. What parts of the course work well as it is, and where do you see potential for change?

The second area of concern is authority. An instructor has authority inherent in his or her position, but a researcher must keep a low profile to avoid activities that might bias results. Consequently, if the researcher must work with students or others involved in the
course, the instructor should vouch for the legitimacy of their actions or the validity of the instrument by including it in course assignments. An alternative would be to have relevant personnel such as teaching assistants administer instruments and interact as needed. In the current research, one of these methods would probably have increased the number of completed pretests and posttests for the learning strategies instrument and decreased its visibility as a research instrument.

The third area involves consistency. A finely tuned plan that provides the researcher and instructor with common understandings and expectations increases the likelihood that methodology will be consistently applied. In this case, the research design that included a control group allowed some flexibility that protected the validity of findings, but the lack of consistency caused unnecessary confusion for students (such as availability of feedback regarding homework) and for teaching assistants (grading policies and practices).

The fourth area of concern is timeliness. Researchers may consider events in terms of cause and effect, consistency, and internal and external validity, so that the sequence of events matters, while instructors may be used to greater flexibility according to characteristics of the students and flow of the course. Constant communication throughout the research is critical to balance the sometimes diverse needs. As an example, for each assignment:

1. the instructor would compose an assignment and pass it to the researcher via email
2. who altered questions for the treatment group and passed it back to the instructor
3. who gave it to office staff for printing then distributed it to students
4. who returned it to lab instructors for grading
5. who passed it back to the instructor
6. who sometimes allowed the researcher access for data collection purposes
7. who then returned it to students via lab distribution sites.

In addition, the instructor composed answer keys that he delivered to a campus shop on a disk for student purchase. Since students were not getting feedback on homework assignments in lab classes, it was important to effect timely return of their assignments.

Commitment is the fifth area. The more involved the research, the greater the need for the instructor and researcher to be committed to the investigation and the welfare of the students. The current research involved a semester-long effort that added to the already high level of responsibilities, stress, and time commitments. Teamwork and some flexibility, powered by commitment, were required to persevere and avoid shortcuts. To continue the same example, the homework construction process outlined above required efforts above and beyond usual office hours.

The sixth area involves access to information that may be restricted for an outside researcher. Educational research involves sensitive consideration of historical data involving students, personnel, and/or events. Permission to use information and access to it provides more informed results. For instance, in the current problem, it would be interesting to compare past gender ratios and patterns of achievement. Ideally, sufficient access to information would be granted during the planning stages. Access may involve:

1. consent for human subject research; at MSU-Bozeman researchers apply for consent which is determined by a Board;
2. signed waivers;
3. coordination with university personnel such as Admissions, the Registrar's office, the instructor, or the Office of Institutional Research; or,

4. permission and access to a relevant database and knowledge of how to use it.

The seventh and final area is extension and application of the research. Several examples of application are:

1. Treatment results are not always fully apparent within the time constraints of the research: for instance, some SI research shows increased performance during the semester following treatments.

2. Results indicate educational changes that should be implemented. If research results strongly indicate a direction for educational improvement, it would be ethically correct to implement improvements.

3. Results indicate follow-up research that should be conducted. In the current case, further research could determine if gender differences are present when the treatment is not practiced.

In cases where the researcher and instructor are distinct individuals, lines of responsibility become blurred. In the current research, for instance, 1.) the relationship to SI indicates that a comparison of longterm outcomes for students in the treatment and nontreatment groups could be of interest; 2.) results indicate constructive changes that could be implemented; and 3.) follow-up research is indicated. While these issues are not necessary to the initial research, they speak to the general value of research and to the interest of the research team in practical consequences.
Summary

Demographic analysis showed that statistically significant gender differences occurred among students in the non-treatment group so that women earned higher scores in homework and labs while men earned 9.65% fewer A and B grades, 6.16% more C and D grades, and 3.49% more F and W grades than women in their group or men and women in the treatment group. There were also indications that mid and low range students in the treatment group tended to get higher overall grades and passed the course at a higher rate than students in the non-treatment group, but these findings were not statistically significant and so were inconclusive. However, the numbers are compelling in that the treatment group had 6.5% more B grades, 5.2% fewer C grades, and a 2.3% higher pass rate than the non-treatment group.

In addition, the findings tend to agree with homework research data, showing that students beyond middle school age benefit in terms of learning from homework (Cooper et al, 1990), and with Supplemental Instruction data that support peer learning through use of study strategies (Martin, 1998). The particular pattern of a lower withdrawal rate and increased success for mid-range students of the treatment group (more B’s and fewer C’s and withdrawals) agree with SI data, but the gender-related aspect may be unique.

In regards to the second research questions, the comparison of pre- and posttest results for the Learning and Study Strategies Instrument (LASSI) and qualitative interviews with students indicated that the treatment did not affect students’ use of learn strategies or metacognitive awareness of them. This is also in keeping with previous findings that assimilation of learning strategies occurs when students are made explicitly
aware of them and encouraged toward metacognitive oversight of their own learning.

Given that the modeling and feedback components of the research plan were not fully implemented, these findings were not surprising.

The answer to the remaining qualitative question, in terms of ease of use and cost, was the use of structured homework assignments manageable from the instructor's perspective, remains debatable. From his experience with the research and prior to learning the answers to the first two questions, the instructor said that he was unlikely to continue the investment of time and effort necessary to create homework assignments and answer keys. However, there was no financial cost and during the subsequent semester of chemistry, he implemented a modified program of structured homework assignments, reducing the emphasis on group work and using assignments from the book as needed. Other instructors may be open to alternative formats that encourage the functional elements of peer learning and the use of SGCP strategies and that provide modeling and feedback on the use of strategies.

Recommendations

Despite the complexity of the research findings, the consistency of success of students who participated in the treatment group speak to its efficacy in assisting students to learn and to persist. The initial research model was based on educational programs of instruction and literature that indicate that learning can be enhanced at the college level by promoting use of study skills, group interaction, and attention to how to learn. The particular format followed in the current research lacked elements of structure that would likely have enhanced student learning and its observable effects. According to the review
of literature, modeling appropriate social interaction and providing feedback on students’ responses to homework questions would provide reinforcement and direction that would tend to reduce students’ confusion and increase efficacy. However, even without use of modeling and feedback, the course instructor reported that the test strategy added unwelcome burdens to his instructional responsibilities. Therefore, recommendations must address these issues.

**Procedural Adjustments**

Researchers might adjust the procedure to improve upon the original research design, to test elements of the design, to alter it for different instructional situations, to improve its manageability for instructors, or some combination of the above. For the course under study or a similar course, one adjustment that could potentially solve several problems at once would be to involve teaching assistants in portions of the research such as administering a pretest and posttest of the study skills inventory, modeling use of study skills, and providing feedback of homework. A graduate student in chemistry education could conduct weekly TA training sessions and be responsible for designing homework assignments and answer keys. There would likely be an increased cost in paying for the graduate student’s time, but the potential for increased retention and conditions favorable to equity in learning would be arguments in favor of such an expense, which would still be less than traditional Supplemental Instruction. Since other TA’s assist in labs and the chemistry help center, their additional training could be ancillary to other duties.

Alternative research designs could be used to test elements of the structured homework model in that random assignment to different groups could test:
1. structured assignments without social learning groups;
2. structured assignments with social learning groups;
3. unstructured assignments with social learning; and,
4. unstructured assignments without social learning groups (control group).

Alternatively, structured homework could be compared to structured in-class assignments or to a combination of problems involving calculations and SGCP journals graded portfolio style. As with Supplemental Instruction, structured homework assignments could be devised for any course with challenging content and a history of student failure.

The current research speaks to the transferability of the “active ingredients” of the SI paradigm: learning strategies that help students to identify and learn important course concepts, interaction with fellow students regarding their learning, adequate feedback on learning exercises and generation of questions for meaningful interaction with instructors.

Instructors can potentially learn from composing structured assignments as that task requires re-evaluation of old concepts in relation to new learners and basic tenets that can help students to predict within their field. Additionally, attention to the considered questions that students compose through the active learning process allows instructors to re-evaluate the effectiveness of their teaching and instructional materials. Finally, the use of homework at the college level is intrinsically valued but poorly researched, leaving the field wide open for variation in design.

New Questions

The research on structured homework assignments gave rise to a host of new questions for further research, including the following.
1. What is the knowledge level of entering freshmen regarding study skills? Where and how did they learn how to learn? How do they monitor their own learning?

2. What percentage of students and which students attend to written advice on study skills such as tips embedded within textbooks, suggestions given on instructors’ syllabi, and less specific tips available across campus?

3. Can acquisition of study skills be enhanced in content courses such as chemistry by asking homework questions such as: Compare and contrast three study suggestions given in chapter two and explain if and how they improved your learning?

4. To what degree do students put effort into homework and labs when they are concerned about earning a grade lower than that to which they aspire?

5. Do women who participate in male-dominated courses and courses of study put greater effort into their study than women in other areas of learning?

6. Do all populations of students react equally to greater or lesser emphasis on homework, tests, labs, and other measures of learning?

7. How does students’ use of learning strategies change throughout their undergraduate years? What percentage of graduating seniors are adept at learning and metacognitive oversight of learning?

8. What are the various uses of homework at the college level and to what degree do they account for learning in different content areas?

9. In courses and major areas of study where enrollment is skewed towards males (such as chemistry and engineering), do men and women report similar amounts of test anxiety?
Structuring Assignments for Courses

The principles that were used in designing the current research are applicable to other courses at the college level. The basic elements to consider are:

1. the particular challenges inherent in the subject matter, such as underlying knowledge expected at entry (math, vocabulary, or other), the level of difficulty of content, or the need to understand new ways of learning such as use of narrative in historical texts;

2. particular challenges inherent in the course, such as difficult textual material, high expectations for student autonomy in learning, or speed of delivery; and,

3. the potential uses of homework assignments to structure students’ learning.

Considering these factors, assignments can be devised that provide supplementary structure to assist student learning. Structure may consist of:

1. asking questions that help students identify and learn basic knowledge, vocabulary, and ways of learning;

2. asking questions in a manner that requires students to use summarizing, clarifying, generating questions, and predicting strategies;

3. including suggestions to assist students in assimilating effective study methods;

4. encouraging students to work on homework in groups with classmates;

5. providing feedback in a manner that models use of study strategies and correct or expected responses (especially important early in the course); and,

6. being explicit about what can be done to learn the material, why it is done, and why one answer may be more correct or elegant than an alternative answer.

Feedback to students should be planned with consideration of the instructor’s time and energy. The purpose of the supplemental assignments is to provide an improved
format for student learning rather than additional opportunities for students to earn
grades. Therefore, portfolio or intermittent grading and feedback may be preferable to
instructors than more standard practices that require regular attention.

Chapter Summary

Many of the more challenging college courses rely heavily on student learning
that occurs outside of the classroom. Despite this, little attention has been given to
directing students’ learning through development of study skills or homework
assignments that elicit use of study skills. In the research on structured homework,
students identified seven ways in which course assignments help them to learn:
1. Assignments help identify material that is important;
2. they provide practice in going through the steps of problem solving;
3. they provide intermediate due dates that keep students on track with their studying;
4. they help students to make sense of what they are learning;
5. they provide an opportunity for social interaction in study groups that helps students
   increase efforts to learn, work regularly on studies, and increase confidence
   regarding learning;
6. they provide an opportunity for feedback regarding the correctness of students’
   understanding; and,
7. assignments give students an opportunity to apply study efforts toward their course
   grade, improving their sense of control over course outcomes.
The research results suggest the implied interaction of homework on cognitive and affective factors listed above and also support structuring assignments to direct students in the use of relevant study strategies. The treatment group, in which students reported collaborating on homework in groups averaging 2.14 students compared to the non-treatment group’s 1.14 average, and whose homework assignments included questions that led students to summarize chemistry concepts, generate questions, clarify, and predict, had generally better course outcomes than the non-treatment group and showed statistically significant differences in specific areas. These findings include:

1. 2.3% more students in the test group passed the course than in the control group;
2. Men in the treatment group did more homework and achieved higher grades on homework, labs, and in the course than men in the non-treatment group;
3. Women in the treatment group persisted to the greatest extent of all students while women in the non-treatment group withdrew at the highest rate;
4. Women in the non-treatment group earned grades equivalent to women and men in the treatment group but had the highest grades of all other groups on homework and labs;
5. Men and women in the treatment group and women in the non-treatment group earned similar grades while men in the non-treatment group had statistically lower grades, earning 9.65% fewer A and B grades, 6.2% more C and D grades and 3.5% more F and W grades than students in the other groups.

These findings and their agreement with past research lead to the conclusion that women in the treatment group gained support on affective factors that helped them to persist while men gained in cognitive areas, improving homework, lab, and overall grades.
The part of the research design that would have led to modeling of the use of learning strategies and greater feedback on homework assignments was not fully implemented due to factors within the course structure. Consequently, students received less explicit coaching in the use of learning strategies and of homework results than was planned, and there were no discernable differences between the two groups on acquisition or knowledge of learning strategies. However, this led to identification of seven potential areas of concern for educators who perform collaborative research in a course taught by another. The areas are:

1. initial mutual lack of knowledge between the instructor and researcher regarding details of the instructional components of the course and the organizational intentions, requiring constant and thorough communication;
2. lack of researcher authority inherent in being the instructor;
3. need for consistency within the fluid workings of an educational situation;
4. concern for timeliness in regards to the sequence of events;
5. ongoing commitment to the research by both the researcher and the instructor;
6. access to information that provides historical background and demographic information; and,
7. concern for follow-through in tracking changes, implementing change indicated by the research, and performing or advising follow-up research.

A suggested change in course design that would make the use of structured assignments less demanding for the instructor would be to assign a graduate teaching assistant the job of designing course assignments and answer keys and training other TA’s to provide better feedback in labs and the Help Center.
Perhaps the most important aspect of the research on structured homework was that it raised questions about how homework affects learning at the college level, how students learn, and how they learn to learn. Given the dependence of higher education on students' ability to learn outside of the classroom, these issues are clearly important. The results of this study show that diverse populations of students experience significant change from alterations in homework assignments. The small but consistent direction to work with one or more classmates on homework and to examine course concepts through the strategies of summarizing, clarifying, questioning, and predicting resulted in assisting general chemistry students to succeed equitably. It was also gratifying to find that students made the semester-long effort to meet in groups just because they were assigned to do so. However, students tend to do that which is assigned and graded, and appear to benefit from the assigned use of study strategies. A final area of importance was the indication that college students are able to successfully apply the basic structure of the Reciprocal Teaching /Supplemental Instruction learning model to informal study groups with minimal direction from their instructor. These findings bode well for the future of structured learning assignments.
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APPENDIX A

HOMEWORK INSTRUCTIONS AND STUDY TIPS
**STUDY TIPS:**
The study of chemistry requires four types of skills:

**Mathematics:** the course prerequisite is two years of high school algebra or eligibility for college calculus. Review math skills, measurement conversions, and use of your calculator.

**Problem-solving strategies:** the ability to ask questions and see beyond simple algorithms or formulas is essential to understanding chemistry. Develop problem-solving skills through active learning strategies:
1) Review notes right after class to assist in understanding and memory of class discussions;
2) When learning formulas, pay special attention to when they are used, and why;
3) Articulate concepts: To be sure you understand concepts from the text or lecture, put them in your own words through writing, speaking, and, best of all, through discussion with a fellow student;
4) Organize your approach to solving problems through a logical series of steps:
   a) identify what the problem is asking;
   b) decide what information is needed to solve this problem;
   c) correctly apply the information to solve the problem; and
   d) go over the answer to verify that it is reasonable.
5) When you do not understand something, write out your questions using steps 4a) and 4b) above to determine just what you do and do not get. If you still do not understand, please ask.

**Conceptualization:** define, explain, draw diagrams, seek or devise examples—do whatever helps you to “see” the concepts and learn beyond mere memorization.

**Theories and chemical language:** The sooner you learn and memorize terms, facts, concepts, and rules that are used in chemical language, the greater will be your understanding of lectures, readings, and test questions. Many students find that it helps to highlight the parts of their text and notes that must be memorized, or to copy material on index cards. Look over chapter headings and illustrations, and read the chapter summary before going to a lecture on the material, then read the entire chapter following the lecture—this system allows the text and lecture to reinforce your learning rather than to cause confusion.
WORKING IN GROUPS:
You must work with at least one other Chem 131 student to complete homework assignments for full credit (groups of three is best). Please put the following information at the top of all homework assignments, and have others in your group initial their names.

student______________________________
lab section # _______________________
due date____________________________
students in group_____________________

FINDING STUDENTS FOR GROUP WORK:
You may work with any Chemistry 131 student; however please note that students in Wednesday or Friday labs do not have identical homework to students in the Tuesday or Thursday labs. For your convenience, the following places are available for group work:
Gaines Hall room 312 is reserved MWF 2:00-5:00 p.m. throughout the semester for Chem 131 students to meet (seats about 30).
North Hedges Conference Room off the main lobby is reserved Sunday evenings, 5:00-10:00 p.m. for Chem 131 students. Non-dorm students are welcome as well (seats about 60).
Renne Library has group study rooms on the third floor that may be reserved by individual students for 2-4 hours—tape a “Chemistry 131 Study Group” sign (provided below) to the door to invite other students in.
The SUB: Check out the Chem 131 study group sign from the Ask-Us Desk to form a study group in the cafeteria area—if it is already checked out, look for the student or group and join them.
Professor Sunner’s help sessions: Connect with other students at the Monday evening help sessions, 6-8 p.m.

FOLD PAPER IN HALF AND DISPLAY ON STUDY TABLE TO ATTRACT FELLOW STUDENTS

CHEMISTRY

131

STUDENTS WELCOME
HOMEWORK: WORKING IN GROUPS:
Working in groups is optional for students in your lab section. If you work with another Chem 131 student (or more), please note their names (for statistical purposes only) at the top of your homework assignments as follows:

student___________________,____________
lab section #__________________________
due date_____________________________
students in group (optional)__________

FINDING STUDENTS FOR GROUP WORK:
You may work with any Chemistry 131 student; however please note that students in Wednesday or Friday labs do not have identical homework to students in the Tuesday or Thursday labs. For your convenience, the following places are available for group work:
Gaines Hall room 312 is reserved MWF 2:00-5:00 p.m. throughout the semester for Chem 131 students to meet (seats about 30).
North Hedges Conference Room off the main lobby is reserved Sunday evenings, 5:00-10:00 p.m. Non-dorm students are welcome as well (seats about 60).
Renne Library has group study rooms on the third floor that may be reserved by individual students for 2-4 hours—tape a “Chemistry 131 Study Group” sign (provided below) to the door to invite other students in.
The SUB: Check out the Chem 131 study group sign from the Ask-Us Desk to form a study group in the cafeteria area—if it is already checked out, look for the student or group and join them.
Professor Sunner’s help sessions: Connect with other students at the Monday evening help sessions, 6-8 p.m.

FOLD PAPER IN HALF AND DISPLAY ON STUDY TABLE TO ATTRACT FELLOW STUDENTS

CHEMISTRY 131
STUDENTS WELCOME
APPENDIX B

QUALITATIVE SURVEY INSTRUMENTS
Qualitative Instrument for Instructor, Chemistry 131, Fall, 2002  Date: _________

1.) How long, or for how many semesters have you taught the general chemistry course at MSU?

2.) What are the most challenging aspects of teaching this course?

3.) How do you think this semester went?

4.) Other than the changes caused by this semester’s research, was there anything unusual about the students or the semester that you think might have affected students' grades?

5.) The research itself caused some problems this semester. Can you explain from your perspective how it affected your teaching and the ability of the students to learn?

6.) What changes did you make to offset problems you encountered?

7.) Prior to this semester, you assigned homework problems from the book and students purchased a solutions manual. Restructuring the chem. 131 homework assignments added to the work involved in teaching the course. Can you elaborate?

8.) If you wished to use restructured assignments in future semesters, do you see a way to make it less work-intensive?

9.) The point of restructuring assignments was to promote learning of course content. How do you feel that turned out?

10.) If learning improved, do you feel the gains were worth the extra effort?

11.) Many of these students will now go on to take Chemistry 132. Do you plan to make any changes to the way you structure assignments in that course as a result of your experiences this semester? How about next fall when you will again teach Chemistry 131?

12.) Based on your experiences this semester and past experiences, and given that courses such as chemistry 131 are challenging to most students, do you have any suggestions on ways to improve student learning through homework assignments?

13.) Essentially the intent of the research was to shift responsibility for student learning toward students by using structured course assignments to elicit use of learning strategies. How do you think that turned out?

14.) Do you have any suggestions to promote students’ use of learning strategies?
15.) In recent interviews, suggestions from your Chemistry 131 students to improve learning include assigning more homework problems and assigning problems with ready solutions such as those in the book. Do you feel assigning structured problems along with problems from the book would be feasible?

16.) Aside from the problems caused by the research in that Tuesday/Thursday lab students had different assignments from Wednesday/Friday students, how easy or difficult is it to use structured assignments over those in the book?

17.) Are there commercially available products that you feel would elicit use of learning strategies among chemistry students?

18.) From your knowledge of Supplemental Instruction, how do you think the structured homework assignments compare to it in affecting student learning?

19.) That's it then. Is there anything you would like to add?
Interview Questions for Lab Instructors: Lab # day____ Date: __/__/____

Name:_________________________________

1.) How long, or for how many semesters have you been a teaching assistant for the general chemistry course at MSU?

2.) What are the most challenging aspects of teaching this lab?

3.) How do you think this semester went?

4.) Other than the changes caused by this semester’s research, was there anything unusual about the students or the semester that you think might have affected students' grades?

5.) The research itself caused some changes in homework protocol this semester. Can you explain from your perspective how it affected your teaching and student learning?

6.) What changes did you make to offset problems you encountered?

7.) Do you also work in the Chemistry Help Center? How did that go this semester?

8.) The point of restructuring homework assignments instead of just assigning end-of-chapter problems was to promote learning of course content. How do you feel that turned out?

9.) It was also designed to shift responsibility for student learning toward students by causing them to use learning strategies such as summarizing important points, clarifying their understanding, generating questions, predicting, and visualizing. Do you think that happened?

10.) During the first six weeks of the semester, half of the students were required to work in groups and the other half were encouraged to do so. Did you get a sense of how that worked out for students?

11.) If the professor wished to use assignments similar to those given this semester in future semesters, do you see a way to make it less work-intensive for TA's?

12.) Based on your experiences as a TA and a chemistry student, and given that courses such as chemistry 131 are challenging to most students, do you have any suggestions on ways to improve student learning through homework assignments?

13.) Do you have any suggestions to promote students’ use of learning strategies?

14.) That's it. Is there anything you would like to add?
Focus Group Survey: Chemistry 131, Fall, 2002 - For Tuesday or Thursday Lab Students

1.) Do you feel you understand the chemistry concepts the course was designed to teach?

2.) If so, what contributed most to your learning? (A previous course, the text, homework assignments, lectures, help sessions—please mention whatever seems most relevant.)

3.) In general, how do you feel the homework assignments affected your learning in this course?

4.) You were not required to work on homework assignments in groups, but were encouraged to do so. Which did you choose to do and how did it work out for you?

5.) Do you feel your study habits in chemistry improved over the semester? Can you explain further?

6.) The first homework assignment included study tips specifically designed to assist in learning chemistry. Did you find these useful?

7.) Did you apply similar strategies to other courses this semester, or do you plan to do so in the future?

8.) Do you have any suggestions for ways other than those used in this course to structure homework assignments to help you to learn chemistry?

Your instructors and future chemistry students thank you for taking the time to share your ideas!!
Focus Group Survey: Chemistry 131, Fall, 2002 – For Wednesday or Friday Lab Students

1.) Do you feel you understand the chemistry concepts the course was designed to teach?

2.) If so, what contributed most to your learning? (A previous course, the text, homework assignments, lectures, help sessions—please mention whatever seems most relevant.)

3.) In general, how do you feel the homework assignments affected your learning in this course?

4.) During the early weeks of the semester you were required to work on homework assignments in groups, and later were encouraged to continue to do so. Did you actually work with one or more other students on a regular basis? Why or why not?

How did working alone or with other students work out for you?

5.) Do you feel your study habits in chemistry improved over the semester? Can you explain further?

6.) The first homework assignment and other assignments included study tips specifically designed to assist in learning chemistry. Did you find these useful?

7.) Did you apply similar strategies to other courses this semester, or do you plan to do so in the future?

8.) Do you have any suggestions for ways other than those used in this course to structure homework assignments to help you to learn chemistry?

Your instructors and future chemistry students thank you for taking the time to share your ideas!!
APPENDIX C

THINGS TO CONSIDER IF LASSI SCORES WERE LOW OR AVERAGE
Things to consider if your LASSI scores were average or low:

The 10 subscales of the LASSI fall into three categories, those that require skill in knowing how to learn, those that require "will," or the determination to succeed, and those that require learners to self-regulate their own learning. Skill is represented by the measures Information Processing, Selecting Main Ideas, and Test Strategies. Measures of will include Anxiety, Attitude, and Motivation. Measures of self-regulation are Concentration, Self-Testing, Study Aids, and Time Management.

Measures of Skill in Learning:

Information processing involves organizing learning in meaningful and memorable ways. This includes strategies such as paraphrasing, summarizing, creating analogies, outlining, idea mapping, generating questions, and predicting what will be on a test and how it will be worded.

- Relate new material to information you have already learned. Seek connections also in various materials instructor presents and wonder, for instance, what concept a demonstration, example, or story is intended to illustrate. Have an enquiring mind.
- When learning theories or formulas, note variations on them and why and when each is used.
- Explain things to yourself, a study partner, tutor, or willing pet. Watch for "holes" in your understanding, then find answers to your questions through further thought, research or questioning.
- Create analogies, outlines, concept maps, sketches and graphs; find memorable examples.

Selecting main ideas is an ability central to understanding how information is related to each other and how it fits together in a coherent and memorable way. It involves recognizing important concepts and supporting details, and knowing what to study and why it is important. To improve this ability:

- Highlight key points in text and notes from lecture.
- Predict possible essay questions an instructor might write, then outline how you would answer.
- Attend study skill workshops on note-taking (Cornell method) and reading texts (PQ4R method).
- Select & compare main ideas from lecture & texts with study partner or tutor; read chapter summaries.
- Observe how knowledge is constructed, using what you know as a scaffold to build new understandings.

Test strategies include test preparation & test-taking skills. Students who feel their test scores are not an accurate indicator of what they have learned should attend a study skills workshop on testing-994-4541.

- Test preparation: Follow all of the advice listed on these pages and attend review sessions. Several days before the test, create a study sheet that organizes information you must know—names, dates, formulas, important concepts, key words—in a brief,
memorable format. Create strategies to assist you to memorize material. Memorize your study sheet then put it aside and see if you can re-create it from memory. Try this three or more times until you get it right. Practice occasionally. Get enough sleep, be on time for your test, bring scratch paper, and do the following:

- Test-taking: Recognize that your brain must take turns accessing memory and thinking on tests—it cannot do both simultaneously. So do the following: 1) Before looking at the test, re-create your study sheet on scratch paper to unburden your memory and bring your attention quickly back to subject at hand; 2) quickly review the test to estimate the length of time needed for various parts such as essay questions; 3) jot notes on scratch paper as they occur to you; for instance, points to cover on essay questions; 4) begin with easiest questions then go back to others; 5) cover answers to multiple choice while reading question then look for correct answer instead of just trying to identify it; 6) briefly outline essay answers before writing and include vital key words in answer; 7) review for careless or clerical errors.

Measures of Will in Learning:

Anxiety interferes with learning—with the enjoyment of learning and with attention, memory, and the ability to think.

- Learn strategies to cope with anxiety—free at campus study skill workshops and the Counseling Center.
- Be pro-active about learning: preview the chapter and read the summary before the lecture, keep up with assignments, work with study partners, over-learn test material.
- Ignore grades as much as possible and concentrate on learning and long-term goals.
- Practice relaxing—breathing, visualizing, exercising, meditating.
- Use tutors, help sessions, and instructors' office hours when material seems too tough to learn alone.

Attitude affects persistence factors such as trying alternative methods when the first doesn't work, and putting in enough study time, in hours, days, weeks, months; it also affects the ability to remember information and ability to recognize importance or meaningfulness of concepts. To understand the importance of attitude, consider the statement by world-renowned educator Albert Bandura: "Unless people believe they can produce desired effects by their actions, they have little incentive to act" (1997). Ways to improve attitude:

- Recognize that attitudes are changeable; you can choose to keep the one you have or choose to change it.
- Work to identify or set goals, then consider how topics you are studying are relevant to your goals.
- Learn to direct your time and behavior, then view classes, assignments, tests, and papers, as choices rather than obligations.
- Don't wait to be "in the mood" to study. Being proactive puts you in control and increases confidence and enjoyment, which changes drudgery to challenge. In other words, study and your mood about studying will improve.
- Spend some time thinking about what is important to learn and why—this helps your memory cooperate by retaining important information.
Motivation is similar to attitude but affects the task at hand where attitude can apply to learning in general. Attitude answers why you might want to learn; motivation is when, or why you want to do it now.

- Procrastination is usually caused by a feeling of doom, an underlying feeling that the task is too difficult. Find ways to break the task into parts then organize the parts. For instance, to write a paper, steps might be: 1- choose a topic, 2- find & read articles on topic, 3- narrow the topic & write a thesis statement, 4- decide main points that support the thesis and use them to write the first sentence of each paragraph, 5- use your thesis and main points as an outline to write the rest of your paper.

- Set specific, clear goals, then take the first step, making each step small enough to understand & do well.

- When you finish one assignment, do the first step of another before taking a break. It's easier to complete a task than to begin a new one.

- Work with others—tutors, study groups, help centers. Make appointments and prepare.

Measures of Self-Regulation in Learning:

Time Management involves making decisions and choices about when to attend to the tasks of education and how much time to delegate for them. Some students plan everything else first (jobs, home-life, & recreation), then fit classes and studying around them. That's a choice.

- Plan realistic amounts of time for educational tasks. Recognize that learning is time-consuming. Write your plan on a weekly schedule and to-do list. Update as needed.

- Decide to attend classes, then take 15 minutes right after class to think deeply through the material that was discussed to process it and move it into your long-term memory.

- Avoid crises by keeping up with studies, reading, and assignments. Read chapter summaries and vocabulary before lecture; get help with problems you can’t solve alone. Study early in the day.

- Set priorities and say “no” to activities that conflict with your goals.

Concentration skills are a combination of focusing attention on learning activities such as reading texts, listening in class and studying, and avoiding becoming distracted by one’s own thoughts, emotions, and feelings.

- Tend to interfering physical demands like hunger or thirst, temperature, sleep needs, and poor lighting.

- Keep lists as needed to reduce the need to remember—this frees the mind to concentrate.

- Deal with personal issues that are troubling through problem solving or seeking assistance.

- Listen actively in class, jotting notes and questions as they occur to you.

- Use the PQ4R method of reading to assist with concentration. Attend campus study skill workshops to learn PQ4R and other ways to make learning more efficient and effective.

- Choose courses wisely on the basis of your interests, course reputations, and texts that will be used to be sure they are relevant and interesting to you. Then stick with your choice. Decide to succeed.
Study Aids draw attention to important material and help with understanding and memory. Textbooks abound with study aids, instructors provide others, and students can create their own, highly effective aids.

- Recognize chapter headings, italics, bold type, definitions, and other cues as study aids.
- Answer end-of-chapter questions; highlight important text and list key concepts in margins.
- Create a study sheet, then organize and analyze it (how will I know when to use this formula vs. a variation of it? What can I do to help remember this list, order of operations, formula, or date?)
- Predict test questions and key words that the instructor will watch for when grading.
- Check with the instructor (and their website) for study guides, homework solutions, old tests.
- Learn underlying math concepts and how to use the calculator where applicable.

Self-testing and review are essential to monitoring your own learning and level of understanding. Effective learning does not occur passively—it involves active thought to organize new understandings with previous knowledge, to make connections, and interpret information into meaningful questions and answers.

- Go over notes immediately after class to process the discussion and note questions you may have.
- Stop frequently during reading to check understanding by mentally paraphrasing material.
- Communicate concepts you are studying, either in writing or verbally, to discover gaps in understanding.
- Think like a professor: try to identify potential test questions when reviewing class materials, and learn how to apply formulas and theories to real problems. Ask the instructor if you’re on the right track.
- Use test banks and review materials to check your understanding.

* The highest possible score on all LASSI items was 40.

Some of the ideas on these pages are from the LASSI User's Manual, written by Claire E. Weinstein, 1987, H&H Publishing, Clearwater FL.