Incorporating Study Strategies in Developmental Mathematics/College Algebra

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ABSTRACT: ***The purpose of this paper is to discuss the effectiveness of incorporating study strategies in a developmental mathematics/college algebra program. Both quantitative and qualitative data were collected through a quasiexperimental methodology. Results show that students reported increases on the Learning and Study Strategies Inventory (LASSI) scales in study strategy usage, and this new strategy usage was supported by comments students made on open-ended surveys. A discussion of conclusions, limitations, recommendations, and suggestions is also included.***

One of the reasons developmental mathematics exists in the first place is to "serve as part of the 'gatekeeper' mechanism."

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It is not surprising that, with the increase in student enrollment in postsecondary institutions, there has also been an increase in underprepared students entering these institutions (Xu, Hartman, Uribe, & Mencke, 2001). In fact, as many as 40% of all freshmen in four-year colleges and universities require some form of developmental education (Hall & Ponton, 2005). Not only are students weak in mathematics content knowledge, but they also lack many of the skills needed for academic success (Xu et al., 2001).

Developmental education program leaders are being forced to deal with the ramifications of such an influx of underprepared students. One such ramification is student attrition. One of the first studies that investigated the levels of attrition of underprepared students was conducted by Roueche (1968). Through this nationwide study of community colleges, Roueche found that approximately 90% of students who were required to take developmental or remedial education courses either withdrew or failed. Unfortunately, as Barr and Schuetz (2008) state, "there is little convincing evidence that much has changed" (p. 10). Furthermore, the researchers assert that "colleges often pursue recruitment and enrollment management strategies to offset the impact of student attrition more vigorously than trying to understand and resolve the dynamics driving student attrition in the first place" (Barr & Schuetz, p. 10).

A related problem is that many students who take developmental mathematics, in particular, are less likely to graduate from college and are more likely to take developmental mathematics repeatedly. Although minimal research indicating mathematics as the gatekeeper of college graduation can be found, a substantial amount of research shows this to be true at the high school level. For instance, Mathematics Special Professional Interest Network, National Association for Developmental Education (2002) claims that one of the reasons developmental mathematics exists in the first place is to "serve as part of the 'gatekeeper' mechanism by which colleges eliminate students who are not qualified for further study" (p. 2). An indication that developmental mathematics is a stumbling block in the path for graduation is the fact that many students take developmental mathematics courses many times before passing the course if at all. For example, of the 47 participants in the Developmental Mathematics/College Algebra program, 12 students (25.5%) took some form of developmental mathematics course repeatedly, and less than half of these students actually passed the course eventually.

Purpose

Math Fundamentals of Conceptual Understanding and Success (Math FOCUS) was an intensive summer program that provided a hybrid Developmental Mathematics/College Algebra course and accompanying instruction through correlation of mathematics and science (Mireles, 2009a) using Peer-Led Team Learning (PLTL; Cracolice & Deming, 2001) and computer theme modules that link content (Mireles, 2009b). Furthermore, related academic support components addressed college going and success seminars concentrating on applications of the psychology of learning, cognition and motivation, financial aid and matriculation, tutoring, and mentoring. The program was partially funded by the Texas Higher Education Coordinating Board and, as such, incorporated a programmatic-type of evaluation. In addition, research questions focusing on academic performance and use of study strategies address two integral thematic initiatives of the program. The purpose of this study is to evaluate the effectiveness of incorporating study strategies in the Math FOCUS program.

Significance

This study adds to the research knowledge in several ways. There is limited research regarding the acquisition and transfer of relevant mathematical "habits of mind" from the developmental mathematics experience to that of college algebra. The researched program provides study strategies in a mathematical context for both developmental mathematics and college algebra since the courses are paired. Thus, this study adds to the research knowledge primarily in the acquisition as opposed to the transfer aspect.

This study also provides research knowledge specific to the linking of developmental mathematics and college algebra especially through study strategy methods. Cargill and Kalikoff (2007) define linked courses as "classes from different disciplines or interdisciplines that are connected in content, purpose, and organization" (p. 181). The researchers suggest that "linking courses across the curriculum may result in lower attrition rates and improved academic achievement" (p. 187). However, the majority of research regarding linked classes consists of cross-disciplinary links such as writing and psychology (Cargill & Kalikoff), Latin American history and Spanish, or United States history and economics or government (Nutting, 2001). Little research has been done to evaluate the effects of linked mathematics courses.

Immersion is commonly used with respect to learning about cultures, where it is sometimes referred to as community or cultural immersion (Handa, Tippins, Thomson, Bilbao, Morano, Hallar, & Miller, 2008), when participating in internships and professional training (Lappan, 1999), or when learning a foreign language (Reeder, Buntain, & Takakuwa, 1999). However, the idea of teaching mathematics using course immersion is relatively uncharted territory. Thus, another contribution to the research base is the context in which the study strategies were delivered, in a daily intensive summer program occurring throughout the entire day.

Research Question

Do the Math FOCUS study strategy components produce different outcomes in student-reported study strategies as measured by LASSI scale scores?

Study Skill Instruction

There are myriad methods for equipping students with the skills they need in order to be successful in college-level courses. Two of the most common methods are Supplemental Instruction (SI) and strategy integration (such as learning strategies and study strategies). Each of these methods will be reviewed from the general education, mathematics education, and developmental education perspectives.

Supplemental Instruction

Arendale (1994) defines SI as an "academic assistance program that increases academic performance and retention through its use of collaborative learning strategies" (p. 11). However, he also points out that SI is a unique collaborative learning program due to the integration of course content with study strategies.

Many studies have been conducted in order to investigate whether or not SI positively impacts student performance and retention. The majority of such studies have found that SI does indeed have a positive impact on student performance with respect to course grade and GPA (Arendale, 1994; Congos & Schoeps, 1998; Gattis, 2002; Hodges, Dochen, & Joy, 2001; Hodges & White, 2001; Kenny & Kallison, 1994; Ogden, Thompson, Russell, & Simons, 2003; Ramirez, 1997). Such increases in student performance have been attributed to the specific techniques used by SI leaders (Gattis, 2002). Research has also shown that SI provides a positive impact on student retention (Blanc, DeBuhr, & Martin, 1983; Commander, Stratton, Callahan, & Smith, 1996; Congos & Schoeps, 1998; Kenny & Kallison, 1994; Ogden et al., 2003; Ramirez, 1997) which many researchers believe is due to the bonds that students create with other students and the institution through participation in SI (Arendale, 1994; Commander et al., 1996; Ogden et al., 2003).

Researchers have speculated as to why underprepared students may benefit more from SI than other students.

It is possible that the reason SI is successful is due to higher motivation levels of the students who voluntarily attend SI sessions. However, in a study conducted by Gattis (2002), motivation was shown to be a factor in student performance whether the student participated in SI sessions or not. Furthermore, in a study conducted by Hodges et al. (2001), students who were mandated to attend SI sessions still outperformed students who did not participate in SI, indicating that "motivation alone does not account for the significant differences in student outcomes in SI and non-SI groups" (Hodges et al., 2001, p. 146).

With respect to mathematics, Burmeister, Carter, Hockenberger, Kenney, McLaren, and Nice (1994) assert that "the active and collaborative learning that takes place during SI sessions, coupled with extensive solitary practice of mathematics, can make the discipline more accessible to all students" (p. 54). Researchers have found that SI can be effective in developmental mathematics courses (Wright, Wright, & Lamb, 2002) as well as college algebra and calculus (Burmeister et al., 1994).

Several researchers suggest that SI has the potential to most benefit underprepared students (Kenny & Kallison, 1994; Ogden et al., 2003; Ramirez, 1997). Researchers have speculated as to why underprepared students may benefit more from SI than other students. A possibility is that SI sessions "feature safe environments" (Gattis, 2002, p. 35) whereas, "although students are encouraged to participate by interacting in the SI session, they are not forced to do so and may feel less threatened by the process" (Hodges & White, 2001, p. 8). Also, many underprepared students choose to participate in SI because it is not viewed as remediation and lacks the stigma associated with other support programs (Arendale, 1994).

One drawback to SI is that it does not seem to have a lasting impact on performance. Various researchers have found that participation in SI does not affect student performance beyond the semester of participation (Kenny & Kallison, 1994; Ogden et al., 2003). However, the long-term effect on student persistence, especially for students with low initial motivation, has been shown by Ramirez (1997). Although long-term effects are debatable, it is believed that SI has immediate impact beyond the specific course in which it is integrated. For example, Ogden et al. (2003) argue that "the skills and learning strategies practiced in SI sessions [can be]…generalized to other courses during the SI treatment quarter" especially for those students who have been admitted to an institution conditionally (p. 6).

Learning Strategy Instruction

As pointed out earlier, SI is unique in its integration of course content with learning and study strategies. However, learning strategy instruction alone has been shown to have benefits in its own right. Kenny and Kallison (1994) showed that there is a positive relationship between a "well-developed cognitive monitoring system" and the "effective use of learning strategies" (p. 76). In addition, teaching learning strategies in a cognitive psychology course had a significant impact on students' study habits and could also affect student performance in subsequent semesters (McKeachie, Pintrich, & Lin, 1985). Moreover, the researchers found that the teaching of learning strategies had a significant im-

pact on students who experience high levels of anxiety.

Research has shown that study strategy use and student performance are significantly related; moreover, academic success can be determined, in part, by a student's use of study strategies (Diseth & Martinsen, 2003; Yip, 2007). Yip (2007) also asserts that more frequent use of study strategies will result in higher academic performance. Additionally, in order to increase academic performance, study strategies need to be taught to students (Weinstein & Mayer 1986; Yip, 2007). Unfortunately, there is minimal evidence that supports the effectiveness of linking study skills in a mathematics-specific context.

Wadsworth, Husman, Duggan, and Pennington (2007) conducted a study in which the impact of learning strategy development was measured with respect to developmental students participating in an online mathematics course. The researchers found that learning strategies such as motivation, concentration, information processing, and self-testing strategies were significant predictors of final course grades. Furthermore, the researchers support "the inclusion of specific learning strategies embedded within the coursework" as a means of improving student learning (p. 13).

A study to evaluate the effectiveness of a study skills program on conditionally admitted students' behavior (Bender, 2001) concluded that intervention techniques, such as a study skills course, appeared to positively influence at-risk students' behavior. Note that this study provided students with a separate study skills course divorced from content.

Methodology

Setting and Participants

The program was conducted at a four-year, urban university in central Texas in the summer of 2008. The university has an enrollment of over 28,000 students of whom approximately 70% are white and 56% are female. The median age of the students at the university is 22.

A total of 47 students successfully completed the program, meaning they received a nonfailing letter grade (A, B, C, or D). Note that 71 students applied, 70 were accepted, and 50 agreed to participate. The three participants who did not successfully complete the program opted out within the first 3 days of the program. There were 30 females and the average (median) age of the participants was 23.5 (five students were over 50 years old). The ethnicity composition was approximately 56% White, 21% Hispanic, 19% Black, and 4% other. Over half of the participants began the program with a failing Texas Higher Education Assessment (THEA; 2009) score (approximately 66%). Also, nine of the students took the Developmental Mathematics course more than one time each without success, and two of these students had similar experiences with the preceding Developmental Mathematics course.

Research Design and Instruments

A mixed-methods design was used to gather both quantitative and qualitative data. There was no control group and participants were not randomly assigned to the program versus a traditional course. There were three surveys utilized in the study: Learning and Study Strategies Inventory (LASSI) 2nd edition, LASSI Pre-Post Achievement Measure, and the Mathematics Information Survey.

The LASSI is a self-report inventory, widely used in higher education, to assess students' awareness about and use of learning and study strategies related to three components of strategic learning: skill, will, and self-regulation.

Study strategies need to be taught to students.

It focuses "on both covert and overt thoughts, behaviors, attitudes, motivations and beliefs that relate to successful learning in postsecondary educational and training settings and that can be altered through educational interventions" (Weinstein & Palmer, 2002, p. 4) such as the Math FOCUS program. The *LASSI User's Manual* describes the instrument as both diagnostic and prescriptive because "it provides students with a diagnosis of their strengths and weaknesses, compared to other college students, in the areas covered by the ten scales, and it is prescriptive in that it provides feedback about areas where students may be weak and need to improve their knowledge, skills, attitudes, motivations and beliefs" (Weinstein & Palmer, 2002, p. 4). Revised in 2002, the LASSI, 2nd edition consists of 80 items equally distributed among the following 10 scales: anxiety, attitude, concentration, information processing, motivation, self testing, selecting main ideas, study aids, time management, and test strategies.

The LASSI Pre-Post Achievement Measure (available from the JDE) is designed to provide students with a simple way to compare, contrast, and reflect on their pre- and post-LASSI scores. There are no reliability or validity data available. Nevertheless, the tool is used to gather qualitative data.

The Math Information Survey, pre and post, (available from the JDE) was developed by program staff to gather qualitative feedback regarding affective issues such as motivation. Although slightly different questions appear on the pre- and the postsurvey, Question 5 and Question 3, respectively, address study strategies.

Procedures

Students in the Math FOCUS program participated in two courses: Developmental Mathematics and College Algebra. The program was a 5.5-week program with the developmental mathematics offered in the early morning (2 hours) and the college algebra offered in the late morning (2 hours). During the Developmental Mathematics course, study strategies were taught as part of the curriculum and additional assignments from MyFoundationsLab™. The Developmental Mathematics curriculum was aligned to the Texas College and Career Readiness Standards (Texas CCRS; Texas Higher Education Coordinating Board, 2008) and, as such, included elements of process standards (e.g., problem solving and reasoning, communication and representation, connections) and cross-disciplinary standards (e.g., academic behaviors, work habits, and technology).

The MyFoundationsLab™ (Pearson Education, 2010) incorporates study strategies both directly and indirectly. Modules regarding time management, for instance, are available. Students were assigned the 12 study strategies modules on an average of 3 per week. Another aspect of the MyFoundationsLab™ is that it includes modules that connect to reading in order to enhance contextualized learning. For example, one module addresses statistical graphs such as histograms versus bar graphs (mathematics perspective) and discusses the nature of the use of average and "how to" read graphs (reading perspective).

Content activities. On a weekly basis, students could determine if doing a "mathematics theme module" was necessary. If the student received at least an 80% on a pretest covering the material in the mathematics theme module, then they were excused from completing the module. The mathematics theme modules addressed study strategies in four ways: they consistently requested development and maintenance of definition lists, requested multiple representations of algebraic ideas, highlighted common errors, and provided study tips on how to avoid errors.

Participants attended College Algebra class daily for 2 hours. Although the course centered on mathematical functions, the common, traditional curriculum, the instructor incorporated study strategies. For example, the instructor fa-

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cilitated the creation of an organizational chart to assist with the critical ideas surrounding mathematical functions. These types of activities occurred on a daily basis.

The participants were active in lunch seminars four times per week. Generally, on Tuesdays and Thursdays, the focus of the lunch seminars was correlated mathematics and science activities (Mireles, 2009a) utilizing the PLTL instructional technique. Study strategies were not directly addressed although they were inherently woven into the activities. For instance, misconceptions regarding the measurement ideas of weight and mass surfaced and students were asked to find methods for clarity.

Study strategy activities. The learning specialist designed and conducted seven learning/study strategy sessions over the period of the project. The first session focused on the Strategic Learning Model, the theoretical and research-based foundation of the LASSI, and on helping students interpret their scores on the 10 scales of the LASSI. The second session, reducing mathematics anxiety, was presented the next day to ensure that students had an opportunity to explore and discuss their experiences with the topic prior to the first exam. Having students read the chapter on mathematics anxiety (Bass, 2008), complete the two exercises on their mathematics timeline and biography, and self-talk before class created an environment where students were not afraid to share their experiences and feelings about a sensitive topic.

The next two back-to-back sessions involved students analyzing their test preparation and performance on Exam 1. The learning specialist provided a minilesson on different types of knowledge (i.e., declarative, procedural, metacognitive/conditional) and the levels of knowledge according to the revised Bloom's taxonomy (Anderson & Krathwohl, 2001). Then students were provided with an "Analysis of Test Preparation and Performance" handout (adapted from Sellers, Dochen, & Hodges, 2005, p. 354) to evaluate their predictions, preparation, and performance on the first exam and to determine how they could prepare differently for the next exam. The topic for the following day was predicting test questions for Exam 2 using what they had learned about types and levels of knowledge. The class was divided into five groups, and each group was equipped with different topics (i.e., a specific type of algebraic function), written worksheets with instructions, large sheets of poster paper, and colored markers. Their task was to review the assigned topic, create four declarative and four procedural knowledge questions they might expect to see on Exam 2, and identify the level of each question according to Bloom's taxonomy. Afterwards, each group recorded their predicted questions on the poster paper, shared them with the large class, and gave them to the program staff to copy and hand out as exam preparation study guides later in the week.

The fifth and sixth learning/study strategy sessions were held weekly and involved note-taking tips for mathematics and using memory aids and graphic organizers. In both sessions, students were involved in activities such as evaluating classmates' notes, critiquing various note-taking formats and mnemonic devices, and working in small groups to create unique graphic organizers for assigned topics and share them with the large class. In the final session, students entered their post-LASSI scores on their form, then analyzed and interpreted the similarities and/or differences in their scores by responding to the open-ended questions about the areas in which they believed they made the most progress and least progress. They also reflected on what reasons might explain the differences or similarities in their scores and how they could use this information about their pre- and post-LASSI scores for their benefit.

Students whose score decreased...provided generic answers that appear to show little thought concerning the reflection piece.

Staff. The Learning Lab Coordinator carefully chose three Math FOCUS tutors for their expertise, experience, and excellent tutoring records in levels of mathematics above college algebra. They attended orientation and training sessions and later met with the coordinator to discuss effective tutoring and learning techniques, appropriate types of support, and realistic expectations for developmental mathematics students. Two tutors were always available during designated tutoring hours, and when their schedules permitted, the tutors would attend the learning/study strategy lunch seminars and Friday lunch wrap-up sessions. Throughout the program, the tutors met with the Learning Lab Coordinator daily to discuss individual students, any exceptional incidents, and questions or concerns.

Data Collection and Recording

Math FOCUS students were administered online versions of the LASSI pre- and posttests. Upon completion of the online tests, students printed two results pages, one for the program director and one for their own records (there is no total score since this is a diagnostic measure). All LASSI scale scores reported are out of 100. An Excel spreadsheet was used to record the results.

Participants utilized the LASSI Pre-Post Achievement Measure on two occasions. After an initial LASSI was administered, students' scores for the 10 scales were entered under the column marked "LASSI One." At the end of the designated time period (e.g., semester, program, etc.), students entered their post-LASSI scores under the column marked "LASSI Two." Then students analyzed and interpreted the similarities and/or differences in their scores by responding to four open-ended questions. An Excel spreadsheet was used to record LASSI pre- and posttest scores and the differences in the scores; open-ended responses were transcribed into a Word document.

Results

In order to address the research question, LASSI results for 47 students were analyzed using descriptive statistics (see Table 1, p. 18), including data focusing on positive and negative changes (see Table 2, p. 19). Next, paired *t*-tests were used to analyze pre- and postscale scores to measure changes in the students' awareness about and use of learning strategies (see Table 1, p. 18). Responses to the surveys add qualitative evidence.

Anxiety

The anxiety scale measures how concerned students are when they approach an academic task. Lower scores indicate higher anxiety levels. The *t*-test indicates an overall reduction in anxiety for this group of students (see Tables 1 and 2, pp. 18-19) The following comments reflect how the students with changes in this area plan to use this information to their benefit:

- "I will calm down and use student resources more to my advantage."
- "work to reduce test anxiety"
- "work on not being anxious and self destroying"
- "I learned how to manage my anxiety"

Of the nine students whose score decreased, indicating an increase in anxiety, six of the students showed decreases in more than half of the scales. This could mean that these students did not increase learning and study strategy skills or that these students didn't take the assessment seriously. In fact, these students provided ge-

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neric answers that appear to show little thought concerning the reflection piece. For example, "I don't know" or "I'm not sure" were typical responses explaining the reason for differences in scores.

In two cases, however, the students' comments indicate that the results may not accurately depict their beliefs. For example, one student stated that she "…didn't think about the questions the first time around." The other student felt that she made herself "…sound worse than what it really is."

One of the students whose anxiety increased but other changes were positive made these comments in response to the reasons for her differences and similarities in the score: "Anxiety and worry, because I set such a high goal for myself and I worry that I will not reach it." and "The difference in anxiety is due to lack of confidence."

Attitude

The attitude scale measures the students' general attitudes and motivation for succeeding in school and performing school-related tasks. The *t*-test was statistically significant, indicating that students' attitudes towards mathematics and school improved.

A majority of the comments students made when analyzing and interpreting their LASSI results reflected changes in attitudes. For example, one student whose pretest was at 10 and posttest was at 70 made this comment: "Being in the math FOCUS program has completely changed the way I feel about math and my school attitude all together." Another student whose score increased from a 55 to a 99 said that his "new found love for math" was the reason he explained the difference in his scores. Other students whose scores increased made these comments:

- "The difference in my attitude allowed me to get the negative thoughts out and become more interested. No matter what the class or problem, Attitude determines your success";
- "I have learned valuable study skills and attitude management skills";
- "I now know that I do have the ability to change my attitude and habits towards homework, test taking, and my overall class work";
- "No matter what the class or problem, attitude determines your success"; and
- "My attitude about how I approach studying and test taking has changed these past weeks. I have to force myself to change in order to do well in my classes."

Other comments from students attributed their change in attitude to the support services (e.g., study skills and tutoring). All of the students whose scores remained the same were initially greater than 80 except for one student who scored a 50 on the pre- and posttest and disagreed with the results. She stated that "I feel like I have a better attitude and more interest than the first time." Four of the ten students whose attitude scores decreased included comments about the length and intensity of the course in their explanations.

Concentration

The concentration scale measures students' ability to direct and maintain attention on academic tasks. This was the highest percentage of gains comparing all ten scales. The *t*-test shows statistically significant increases, which indicates that students were better able to monitor their level of concentration. Comments regarding concentration were often related to other scale scores, such as attitude and motivation. Others were related to focusing efforts, engagement, and the nature of the program. Students whose scores decreased did not specifically address concentration in their comments. Additionally, these students showed decreases on a majority of the scales.

Information Processing

The information processing scale measures how well students' can retain and apply learned information. This includes using organization strategies and reasoning skills to help connect what they already know to what they are trying to learn and remember. The statistically significant *t*-test scores indicate that students' perceptions of their ability to use organizational strategies and reasoning skills to retain and apply learned material increased (see Table 1). The qualitative data provided little insight to this scale. One student comment revealed reflection on organizational strategies: "My confidence and organizational skills improved each week."

Motivation

The motivation scale measures self-discipline and the willingness to put forth effort. The *t*-test indicates statistically significant increases in student motivation (see Table 1). The following comments provide evidence of how students' motivation changed during the course:

- "I'm motivated and I now have a willingness to work because the opportunity is there."
- "I worked harder, and motivated myself to do it. Therefore my scores improved."
- "My motivation has increased and I have more confidence in myself."
- "Improved attitude and motivation due to positive manner of course & instructor support so I can succeed and learn math."

Of the nine students showing decreases, seven also showed decreases in a majority of the scales. Student comments did not offer much insight to why motivation did not increase, but one student did talk about "burnout" with the subject of mathematics.

Selecting Main Ideas

The selecting main ideas scale measures students' skill at identifying important information for further study. Students reported they were better able to identify important information and less likely to be confused by details (see Tables 1 and 2). No student comments were identified to support or refute any increases or decreases for this scale.

Table 1

LASSI Pre- and Posttest Scores

LASSI Scale	Pre		Post		Change		Test	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	*t*	*p*
Anxiety	41.2	30.6	63.7	32.3	22.5	29.8	-5.167	< .001
Attitude	39.3	28.2	59.9	29.6	20.6	32.4	-4.353	< .001
Concentration	42.9	26.9	67.2	28.9	24.3	26.5	-6.298	< .001
Information processing	57.0	28.0	72.1	23.4	15.1	31.9	-3.255	.002
Motivation	44.4	28.3	65.5	30.1	21.0	31.6	-4.554	< .001
Selecting main ideas	49.2	29.1	72.0	22.3	22.9	25.2	-6.221	< .001
Self-testing	44.7	29.4	66.2	30.4	21.5	36.8	-4.000	< .001
Study aids	47.9	28.0	73.2	27.7	25.3	29.2	-5.954	< .001
Test strategies	46.4	28.5	71.1	25.0	24.6	28.7	-5.893	< .001
Time management	38.6	29.6	69.4	29.0	30.8	27.2	-7.762	< .001

Note. $n = 47$ *and* $df = 46$.

Self-Testing

The self-testing scale measures students' ability to self-regulate their learning by monitoring their level of comprehension to determine their level of understanding. The *t*-test indicates statistically significant increases for this scale, with almost three-quarters of the students showing increases (see Tables 1 and 2). Again, no student comments provided insight to this scale.

Study Aids

The study aids scale measures students' use of resources to help them learn or retain information. Scores signify that students were more aware of resources and more likely to use them (see Tables 1 and 2). Students commented frequently about the benefits of the tutoring services, but students also commented that requiring this activity made a difference in their choices and overall performance. These comments provide evidence of students becoming aware of university resources.

- "I learned a lot in this program about different avenues for studying and help that I was never aware of," and
- "I will definitely obtain the help and resources that the university offers."

Test Strategies

The test-strategies scale measures students' use of test preparation and test taking strategies. Test strategies, together with concentration and time management, realized the highest number of students with increased scores (see Tables 1 and 2). Students provided general comments about improving test-taking strategies, such as "Through the course, I have learned new methods for studying material and preparing for tests." Three students had decreased scores. One of these students explained that she didn't have enough time on the tests.

Time Management

The time-management scale measures students' applications of time-management strategies, such as effective scheduling and monitoring techniques that promote completion of academic tasks, balances academic and nonacademic tasks, and decreases procrastination. Although the *t*-test indicates statistically significant results, there were 3 students (6.4%) who reported decreases. Along with the concentration and test strategies scale, the largest number of students (83%) showed increases in their scores on this scale (see Tables 1 and 2). None of the students' comments related specifically to time-management topics.

Study-Strategy Usage

Additional data documenting changes in student study strategies were analyzed from one question on each of the pre- and post-Math Information Surveys. After coding the students' responses, it was evident that students learned and applied new study strategies in this course.

In general, students were aware that they needed to "do math" to be successful in their mathematics courses. Specifically, 74% (35 out of 47) of the students stated that they studied for previous mathematics courses by working homework problems or practice problems. The students clearly learned new strategies, and this was demonstrated by 79% (37 out of 47) of the students listing new strategies on the postsurvey. Students overwhelmingly listed tutoring as one of the new strategies that helped them the most. In fact, 60% (28 out of 47) listed tutoring as a new strategy they used for this mathematics course. Additionally, students consistently listed studying with other students in groups (19% or 9 out of 47), reviewing materials and self testing (19% or 9 out of 47), and using note cards (11% or 5 out of 47). Other strategies listed by students included working extra problems, completing all of the homework and reviewing the homework at a later time, reading the chapters before class, reviewing notes and the textbook, seeking help from the instructor, studying definitions, using online learning modules, and using tables and graphs. Three students reported that they did not study for the course. However, one of those students specifically stated "I didn't. I just kinda helped others." Interestingly, this comment reveals an important study strategy, working with other students, so it may be that the other two students also employed new strategies, but were not aware of them.

Discussion and Implications for Practice

Students showed statistically significant changes in all scales measured by the LASSI. On average, those changes were positive. In general, students commented most frequently about decreases in anxiety, improvements in attitude, and increases in motivation. However, other themes emerged from the data that are important for and relevant to developmental mathematics students, including changing behaviors, scales influencing other scales, program influence, and future use of study skills learned in the class.

Student's Changing Behaviors

Regarding students' recognition of the need for change, students commented,

- "I now know that I do have the ability to change my attitude and habits towards homework, test taking, and my overall class work," and
- "My scores changed because I was engaged in the class this summer and I communicated effectively with my professor."

Change can only occur once a student has recognized a need for change. This awareness is the first step, but taking action and making the change occur is most challenging for students. One student who showed decreases in all areas has commented that comparing pre- and post-scores "helped me realize that I could do so much better than what I was doing so it gave me a realistic result." This comment indicates that the student has an awareness of her lack of effort towards making changes. Several students recognized the ability to change their attitudes towards mathematics in general.

In order for this change to occur, students

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Table 2

LASSI Descriptive Statistics: Positive and Negative Changes

LASSI Scale	Positive Change		Negative Change		No Change
	Number of Students (%)	Average Change	Number of Students (%)	Average Change	Number Students (%)
Anxiety	35 (74.5%)	34.5%	9 (19.1%)	16.7%	3 (6.4%)
Attitude	33 (70.2%)	35.7%	9 (19.1%)	23.2%	5 (10.6%)
Concentration	39 (83.0%)	31.9%	5 (10.6%)	20.2%	3 (6.4%)
Information processing	28 (59.6%)	33.7%	13 (27.7%)	17.9%	6 (12.8%)
Motivation	32 (68.1%)	37.3%	9 (19.1%)	22.8%	6 (12.8%)
Selecting main ideas	37 (78.7%)	31.2%	3 (6.4%)	26.7%	7 (14.9%)
Self-testing	35 (74.5%)	37.9%	11 (23.4%)	29.0%	1 (2.1%)
Study aids	35 (74.5%)	36.8%	8 (17.0%)	12.4%	4 (8.5%)
Test strategies	39 (83.0%)	32.3%	7 (14.9%)	14.3%	1 (2.1%)
Time management	39 (83.0%)	37.9%	3 (6.4%)	9.7%	5(10.6%)

Note. $n = 47$.

CONTINUED FROM PAGE 19

must be able to employ a variety of the learning strategies measured by the LASSI. For example, students must be willing and motivated to work hard, and they must monitor their strategies for effectiveness. Many students recognized that the scales influenced each other. Students could be charged with designing a plan for changes at this critical moment of awareness to increase chances of transferring study strategies.

Scales Influencing Other Scales

Students were very aware of their level of anxiety and learned specific strategies to focus efforts to reduce this anxiety. For example, positive self-talk and attitude can influence anxiety. Students recognized the ability to change their attitude, learned the strategy to change it, employed the strategy, and then reflected on the successful implementation of that strategy.

- "The first time my results forced me to acknowledge what my weaknesses were. This time around, I am happy to see improvement and I'm motivated to continue working on the things that still have room for improvement," and
- "Self-testing and motivation really go hand and hand because I don't have the motivation to test myself."

Self-testing and comparison of programs might be applied to content as well as study strategies to augment success.

Program Influence

Many participants attributed changes in scale scores to the design of the program. In particular, the rigid schedule as well as the required elements imposed structure on participants' study and learning habits. Some comments by participants that support this claim include

- "This class helps students in all areas by guiding us w/ lots of structure,"
- "I think the program was overwhelming at first then the opportunities presented alieviated [sic] a lot of the stress,"
- "Use of support materials mandatory," and
- "Improved attitude and motivation due to positive manner of course & instructor support feeling I can succeed and learn math."

This finding adds support to the importance of highly structured learning environments for developmental students.

Future Use of Study Skills Learned in Class

Over 50% of the students commented on how the learning strategies in this course will help them in future courses. Many students discussed how they plan to use these valuable tools in future studies and course work. Whether students were able to manage stress and anxiety in more effective ways or able to apply study techniques to focus on big ideas versus details, they commented on their awareness, willingness, and abilities to use these strategies in new situations. The finding that students were not always aware of their new strategy use could be problematic in terms of continuing to use new strategies. Instructors and staff could request feedback from students regarding all their "activities" and point out any that might be an unrecognized study strategy.

Other Points of Interest

Statistical significance was achieved in every scale, reflecting the effectiveness of the program. Information processing was the scale that resulted in the lowest overall pre/post change. Perhaps one of the reasons that information processing realized the lowest positive change may be due to participants' lack of previous content knowledge and thus inability to make the necessary connections. Also, the organizational strategies were concurrently addressed along with content knowledge acquisition, and this may have blurred the delineation from the participants' perspective as to what the change agent actually was.

Many participants attributed changes in scale scores to the design of the program.

Of the scales with the highest number of participants with positive change—concentration, test strategies, and time management—only time management coincided with self-testing as scales yielding the highest average positive change. Time management, also the scale with the largest overall change, may have surfaced to the top primarily because of the imposed structure of the program. Highly structured programs can reinforce appropriate time-management behaviors.

Limitations

There are two limitations that are program specific. First, note that eligibility requirements were established and students were required to apply. Not all students who applied were accepted into the program. Thus, students were not randomly chosen and an element of competition may have affected their motivation. Another limitation was that the instructors were chosen by the project director particularly because of their effective teaching techniques.

There are additional limitations regarding the methods of this study. First, changes in study strategies are based on self-report measures. Using additional measures to support the data collected from the self-report measures would strengthen the study. Second, an experimental design with randomization and a control group of students who did not receive study skills instruction would extend this study to focus not only on acquiring the skills but also on how study-skills instruction impacts the learning of mathematics.

Recommendations and Suggestions

Through this research, it was found that there is a void in studies that hone in on the specific needs of developmental mathematics students, especially as they relate to the effectiveness of study strategies. A natural extension to the current study is to consider tracking students to ascertain (a) the transfer of knowledge and skills of both mathematics and study strategies to future mathematics classes and (b) graduation success. Although this study found that students self-reported changes in study skills, future studies should consider other measures for reporting changes in study skills and consider using a control group to pin point how study skills directly impact students' learning. Furthermore, a distinction between study strategies and learning strategies through either supplemental efforts or embedded in courses may help fine-tune results achieved in this study.

One of the primary suggestions resulting from this study is to provide structure for students. The structure in this course led to the strong sense of community the students built. For example, since the students were together most of the day, they were able to make strong connections because they had time to build trust and relationships on common ground. Another suggestion for program implementation is to utilize various methods of infusing study and learning strategies. These methods include incorporating the strategies into lesson plans and providing supplemental methods. These methods should tie in mathematical content whenever possible.

Conclusion

Overall, the program proved to be successful in regards to study and learning strategies as reported on the LASSI by participants. In particular, this research study highlighted positive impact on the strategies utilized by developmental mathematics students through study

strategy incorporation in both a developmental mathematics and college algebra class. As study skills improve, so should pass rates. Success in developmental mathematics—a proclaimed "gatekeeper course"—will assist underprepared students' overall success and college graduation.

References

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing*. New York, NY: Longman.

Arendale, D. R. (1994). Understanding the supplemental instruction model. In D. D. Martin & D. R. Arendale (Eds.), *Supplemental Instruction: Increasing achievement and retention* (pp. 11–21). San Francisco, CA: Jossey-Bass.

Barr, J., & Schuetz, P. (2008, Winter). Overview of foundational issues. *Are Community Colleges Underprepared for Underprepared Students? New Directions for Community Colleges*, (144), 7-16.

Bass, A. (2008). *Math study skills*. Boston, MA: Pearson Education Inc.

Bender, D. S. (2001). Effects of study skills programs on the academic behaviors of college students. *Journal of College Reading and Learning, 31*(2), 209-216.

Blanc, R. A., DeBuhr, L. E., & Martin, D. C. (1983). Breaking the attrition cycle: The effects of Supplemental Instruction on undergraduate performance and attrition. *The Journal of Higher Education, 54*(1), 80-90.

Burmeister, S. L., Carter, J. M., Hockenberger, L. R., Kenney, P. A., McLaren, A., & Nice, D. L. (1994). Supplemental Instruction sessions in college algebra and calculus. In D. D. Martin & D. R. Arendale (Eds.), *Supplemental Instruction: Increasing achievement and retention* (pp. 53–62). San Francisco, CA: Jossey-Bass.

Cargill, K., & Kalikoff, B. (2007). Linked courses at the Twenty-First Century Metropolitan University. *Teaching English in the Two Year College, 35*(2), 181–190.

Commander, N. E., Stratton, C. B., Callahan, C. A., & Smith, B. D. (1996). A learning assistance model for expanding academic support. *Journal of Developmental Education, 20*(2), 8-16.

Congos, D. H., & Schoeps, N. (1998). Inside Supplemental Instruction sessions: One model of what happens that improves grades and retention. *Research and Teaching in Developmental Education, 15*(1), 47-62.

Cracolice, M. S., & Deming, J. C. (2001,). Peer-led team learning. *The Science Teacher, 68*(1), 20-24.

Diseth, A., & Martinsen, O. (2003). Approaches to learning, cognitive style, and motives as predictors of academic achievement. *Educational Psychology, 23*, 195–207.

Gattis, K. W. (2002). Responding to self-selection bias in assessments of academic support programs: A motivational control study of Supplemental Instruction. *The Learning Assistance Review, 7*(2), 26-36.

Hall, J. M., & Ponton, M. K. (2005). Mathematics self-efficacy of college freshmen. *Journal of Developmental Education, 20*(3), 26-32.

Handa,V., Tippins, D., Thomson, N., Bilbao, P., Morano, L., Hallar, B., & Miller, K. (2008). A dialogue of life: Integrating service learning in a community-immersion model of preservice science-teacher preparation. *Journal of College Science Teaching, 37*(6), 14–20.

Hodges, R., Dochen, C., & Joy, D. (2001). Increasing students' success: When supplemental instruction becomes mandatory. *Journal of College Reading and Learning, 31*(2), 143-156.

Hodges, R., & White, W. G. (2001). Encouraging high-risk student participation in tutoring and Supplemental Instruction. *Journal of Developmental Education, 24*(3), 2-10, 43.

Kenney, P. A., & Kallison, J. M. (1994). Research studies on the effectiveness of Supplemental Instruction in mathematics. In D. D. Martin & D. R. Arendale (Eds.), *Supplemental Instruction: Increasing achievement and retention* (pp. 75-82). San Francisco, CA: Jossey-Bass.

Lappan, G. (1999). Immersion. *Journal of Staff Development, 20*(3), 34-35.

Mathematics Special Professional Interest Network, National Association for Developmental Education. (2002). *Best practices in developmental mathematics*. Goodyear, AZ: Author.

McKeachie, W. J., Pintrich, P. R., & Lin, Y. G. (1985). Teaching learning strategies. *Educational Psychologist, 20*(3), 153-160.

Mireles, S. V. (2009a). Correlating mathematics and science. *Mathematics Teaching in the Middle School, 15*(2), 100–107.

Mireles, S. (2009b). Developmental mathematics/college algebra theme modules. *NADE Digest*. Manuscript submitted for publication.

Nutting, M. M. (2001). The linked course: A viable option for teaching and learning history. *Teaching History: A Journal of Methods, 26*(1), 3-12.

Ogden, P., Thompson, D., Russell, A., & Simons, C. (2003). Supplemental Instruction: Short and long-term impact. *Journal of Developmental Education, 26*(3), 2-4, 6, 8.

Pearson Education. (2010). *MyFoundationsLab*™. Retrieved from http://www.mathxl.com/login_foundations.htm

Ramirez, G. M. (1997). Supplemental Instruction: The long-term impact. *Journal of Developmental Education, 21*(1), 2- 10, 28.

Reeder, K., Buntain, J., & Takakuwa, M. (1999). Intensity of L2 instruction and biliterate proficiency in the intermediate years of a French immersion program. *Canadian Modern Language Review, 56*(1), 49-72.

Roueche, J. E. (1968). *Salvage, redirection, or custody?* Washington, DC: American Association of Junior Colleges.

Sellers, D., Dochen, C. W., & Hodges, R. (2005). *Academic transformation: The road to college success*. Upper Saddle River, NJ: Pearson Prentice Hall.

Texas Higher Education Assessment (THEA). (2009). Amherst, MA: Pearson Education, Inc.

Texas Higher Education Coordinating Board. (2008). *Texas college and career readiness standards*. Austin, TX: Author.

Wadsworth, L., Husman, J., Duggan, M., & Pennington, M. (2007). Online mathematics achievement: Effects of learning strategies and self-efficacy. *Journal of Developmental Education, 30*(3), 6-14.

Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (pp. 315–327). New York, NY: Macmillan.

Weinstein, C. E., & Palmer, D. R. (2002). *LASSI user's manual for those administering the Learning and Study Strategies Inventory* (2nd ed.). Clearwater, FL: H & H Publishing Company, Inc.

Wright, G. L., Wright, R. R., & Lamb, C. E. (2002). Developmental mathematic education and supplemental instruction: Pondering the potential. *Journal of Developmental Education, 26*(1), 30-35.

Xu, Y., Hartman, S., Uribe, G., & Mencke, R. (2001). The effects of peer tutoring of undergraduate students' final examination scores in mathematics. *Journal of College Reading and Learning, 32*(1), 22-31.

Yip, M. C. W. (2007). Differences in learning and study strategies between high and low achieving university students: A Hong Kong study. *Educational Psychology, 27*(5), 579-606.

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