Group Study as a Form of Support for Developmental Mathematics Students

Tara E. Diehl
Karen J. Hamman
Bloomsburg University of Pennsylvania
Serina Rivera
Florida Southwestern State College

Abstract

Students taking developmental mathematics often struggle with dedicating adequate time to engage with material outside of class. The institution in this study requires participation in out-of-class support and has utilized a variety of models of support. The goal of these support programs is to increase the pass rates for students and aid in the development of study skills that can be transferred to other coursework. The purpose of this study was to compare the academic attainment and study skill development for developmental mathematics students participating in a structured peer study group compared to students who did not participate.

Introduction

Students who begin college with deficits in basic skills, like mathematics, are most at risk of dropping the course and of dropping out of college altogether (Copus & McKinney, 2016). Therefore, connecting students with support can be of "life-changing importance for our students" (Adams, Gearhart, Miller, & Roberts, 2009, p. 67). This study highlights a program that focused on collaborative group study as a form of support for students enrolled in developmental mathematics.

Providing appropriate and effective out-of-class support for students in developmental mathematics has been an ongoing challenge at a public four-year institution in the northeast. Previous forms of developmental mathematics support included a pilot

program of Structured Learning Assistance (SLA) in one section of Intermediate Algebra. The SLA program helped students to achieve higher grades within the class and was then implemented in all sections of Intermediate Algebra following the pilot. Due to the increasing number of students SLA was serving and the strain on resources (space, time, number of SLA leaders, etc.), the SLA program was transitioned into a Math Lab. The Math Lab remains the primary mode of support and serves all sections of developmental mathematics courses offered at the institution. Students enrolled in developmental mathematics are required to attend Math Lab for two hours a week in addition to class attendance. Math Lab leaders are employed to offer assistance, support, and tutoring to the students taking the developmental math classes.

The Math Lab offered a solution to the logistical issues and was a more sustainable form of support for students taking developmental mathematics courses. After a few years of utilizing the Math Lab as the primary form of support, some of the math faculty wanted to create more structure and find ways to increase the collaboration among the students.

Literature Review

Supporting Developmental Mathematics Students

During the planning stage of this initiative, a variety of support models were considered in an attempt to match student needs with appropriate support. While group study seemed like a natural fit, a review of current literature revealed few studies documenting the use of group study for developmental mathematics students. Various other methods used with developmental math students were examined, such as a traditional peer tutoring model, Supplemental Instruction, Structured Learning Assistance, and a peer mentor model.

In a typical peer tutoring support model, where at-risk students were identified and connected early with this resource, Copus and McKinney (2016) were able to generate a 65.6% pass rate for student participants when compared to 56.6% pass rates for all students enrolled. In addition to improving their pass rates, 95.3% of student participants continued to utilize tutoring services

throughout the semester (Copus & McKinney, 2016), which is critical since Arendale (1994) notes that students most in need of assistance are often the ones that do not participate in support services when offered the choice.

Supplemental Instruction typically has not been recommended for developmental mathematics students because the model was developed for high-risk college courses, not high-risk students (Hurley et al. 2006). However, Wright, Wright, and Lamb (2002) reported that Supplemental Instruction in developmental math courses had a slight positive change in course retention and performance. This same study also recommended more instructor involvement in the supplemental instruction process, increased involvement of the Supplemental Instructor in class, and increasing Supplemental Instructor/Class Instructor meetings.

More recently, the City University of New York (CUNY) reported success utilizing Supplemental Instruction (SI) for developmental mathematics over a 2-years (Dias, Cunningham, & Porte, 2016). In this quasi-experimental design, their results included a statistically significant improvement in pass rates for students in sections supported by the SI model when compared to the sections not supported by the program. Specifically, 59% of students in SI sections passed compared to 52% in non-SI sections (Dias, Cunningham, & Porte, 2016). While the pass rates were certainly encouraging, Dias, Cunningham, and Porte (2016) were unable to identify any impact on the retention of this vulnerable population of students. Additionally, the traditional SI model involves voluntary attendance; however, as previously stated, at-risk students are less likely to utilize voluntary support services (Arendale, 1994).

The Structured Learning Assistance (SLA) program addressed this challenge in that it was specifically designed for developmental students and is a required component for students enrolled. Diehl's (2017) pilot results using SLA in some sections of developmental mathematics courses were promising, showing 45% of students in SLA supported sections with a C or higher course grade compared to 24% of students in sections not supported with SLA. This group of researchers hoped for a support model that would yield even more improved academic results while also helping

students develop skills transferable to other coursework.

Finally, the peer mentor model is yet another approach to assist students in developing the skills necessary for success in developmental mathematics courses. Morales, Amrose-Roman, and Perez-Maldonado (2016) noted positive academic and social benefits of having at-risk students work in a mentor-mentee format in support of their developmental mathematics course. They cited significant differences in pass rates of students participating in the mentor program compared to non-participants. Of equal importance, they were able to attribute increased self-efficacy and social integration to students' participation in the program, setting up students for a higher likelihood of long-term success in college (Morales, Amrose-Roman & Perez-Maldonado, 2016).

In a more current study, Deshler, Fuller, and Darrah (2019) developed a similar peer mentor model to support students in developmental mathematics with the hopes of supporting students both academically and socially. They too were able to see some positive impact on students' success, as well as their persistence. Student participants self-reported other benefits including a greater connection to the university and increased enjoyment of their time at the university (Deshler, Fuller & Darrah, 2019).

The review of these models suggests that any support program that involves some type of peer interaction yields positive results, both academically as well as in other domains. These findings encourage continued exploration of other models that rely upon peers assisting one another. The focus was to encourage students to work together in a cooperative learning approach.

Group Study

After a review of various models, group study appeared to be a viable option to support developmental mathematics students, although its use among this population was not well documented. However, cooperative learning models typically yield positive results. For example, Daneshamooz and Alamolhodaei (2012) compared 263 students from three universities on cooperative versus traditional learning. Regardless of their math anxiety levels, cooperative learners performed better in mathematics than traditional

learners. Additionally, Baker and Campbell (2005) conducted a study that focused on the needs of a successful group. They specifically examined undergraduate students in mathematics task groups and suggested that a successful group should be taught problem-solving skills, receive immediate feedback, have monitored progress, receive rewards for performance, be assigned to specific groups, and possess self-efficacy.

In one example of self-initiated study groups formed by students enrolled in STEM courses, Sandoval-Lucero, Blasius, Klingsmith, and Waite (2012) documented that students benefitted from group study by learning different perspectives on class material, as well as new study techniques. Additionally, the students reported an enhanced classroom and social experience and an increased sense of accountability that they attributed to the study groups (Sandoval-Lucero et al., 2012).

Another collaborative-style learning program, the Peer-Led Team Learning (PLTL), measured whether it could expand access to STEM majors for "at-risk learners." (Street, Koff, Fields, Kuehne, Handlin, Getty, et al., 2012). The results of this study showed that PLTL had positive trends in STEM persistence and students' use of effective learning strategies. The GPA outcomes for students participating in the program were also more positive compared to non-participants (Street et al., 2012).

While positive learning experiences and increased learning skills are exceptionally important, it is critical to remain focused on grade attainment and persistence. Quitadamo, Brahler, and Crouch, (2009) found that using Peer-Led Team Learning in STEM courses improved grade performance and retention in both math and science classes and increased critical thinking performance in science classes. In a study with a similar population, peer-led collaborative learning groups were integrated into developmental math classes in a tribal community college (Hooker, 2011). The study reported increased completion rates (the number of students earning a C doubled), increased perseverance rates (fewer students dropped the course), increased student satisfaction with the course, and self-reported growth by students in the areas of social skills and academic skills (Hooker, 2011).

The Learning and Study Strategies Inventory (LASSI)

To address building academic skills as well as improving performance in mathematics, it was important to identify an appropriate assessment tool. The LASSI is a widely used assessment tool that determines students' strengths and areas for growth in ten different key components of learning. The LASSI is a 10 scale, 80-item assessment of students' awareness of and use of learning and study strategies. According to Weinstein and Palmer (2002), the LASSI can be used in a variety of ways to screen, diagnose, and assist students in their development of study skills including as a "pre-post achievement measure for students participating in programs or courses focusing on learning strategies and study skills" (p. 4). The ten LASSI scales are Anxiety, Attitude, Concentration, Information Processing, Motivation, Selecting Main Ideas, Self-Testing, Study Aids, Test Strategies, and Time Management.

Weinstein and Palmer (2002) note that "each of these scales is primarily related to one of three of the components of strategic learning: skill, will, and self-regulation" (p.4). The "skill" components are Information Processing, Selecting Main Ideas, and Test Strategies. Information Processing refers to students' ability to summarize reading and relate new information to prior knowledge while Selecting Main Ideas assesses the ability to identify key points in both lectures and textbooks. The final skill category is Test Strategies, or the ability to study for various types of tests. The "will" components of strategic learning are Anxiety, or the level of worry and distress over grades, Attitude, or students' disposition toward their educational goals, and Motivation, or diligence and self-discipline. Finally, the "self-regulation" components are Concentration, or distraction level, and Self-Testing, or review behaviors. Also included within "self-regulation," are Study Aids, the ability to use practice exercises or create study materials, and Time Management, or organization and scheduling (Weinstein & Palmer, 2002). A study by Mireles, Offer, Ward, and Dochen (2011) found that incorporating study strategies into developmental mathematics courses increased Learning and Study Strategies Inventory (LASSI) scores.

Background Information

This study was developed to find a method to support students in developmental mathematics as an alternative to the math lab format, which had been the current support at that time. Students in the Math Lab tended to sit in isolation and rarely sought assistance from the Math Lab leaders or each other. The goal of group study was to create more meaningful interactions since the faculty teaching math saw collaboration as an essential component to the support program and an important part of students' mathematical development. Anecdotal observations from the math faculty led to the conclusion that many students were not using Math Lab to its full potential. One faculty member noticed that the students were struggling with the same ideas. Rather than re-teach the concept individually, the professor provided the students with an area to work collaboratively to understand the concept. Students were encouraged to ask the professor for assistance if everyone in the group struggled with a concept. As the professor observed these informal groups of students working together, she noticed that the students were learning as much or more from each other as they were from individually meeting with her about their questions. Wanting to encourage this type of collaboration, the researchers wanted to determine if a group study component could be integrated into the current structure and potentially replace it altogether.

One of the researchers in the study teaches developmental math courses in a centralized department of developmental instruction and was the instructor for the courses. Another researcher is the Director of Academic Support Services within the same department, who oversees Supplemental Instruction, peer tutoring, and the Math Lab. The third researcher was a Graduate Assistant in Academic Support Services and the facilitator for the group study program and had completed tutor training aligned with the College Reading and Learning Association (CRLA) practices. The Graduate Assistant met regularly with both the course instructor and the Director of Academic Support Services to review the group study program.

Purpose of the Study

The purpose of this study was to compare grade outcomes and study skill development for developmental mathematics students participating in a structured peer study group compared to students who did not participate in group study. The research questions guiding this study are:

1. Do developmental mathematics students who participate in a structured peer study group achieve higher quiz, exam, and course grades when compared to those who do not participate?
2. Do developmental mathematics students who participate in a structured peer study group develop better study strategies during the semester when compared to those who do not participate?

The first research question involved a quantitative analysis of the following assessments: homework, quiz, exams, final exam, exam averages, and the overall course grades. Independent sample t-tests were performed to analyze the significance of the data. The second research question focused on a quantitative analysis of the results of the LASSI. There was both a pre-test and a post-test measure of the LASSI administered to the student participants.

Structure of the Group Study Program

At that time, Math Lab was the required form of developmental mathematics support offered to students enrolled in developmental math courses. During the study, group study was offered as an alternative developmental mathematics support program. Study participants were given the choice during the first week of class to choose from Math Lab or group study as their support option (Appendix A). Rather than randomly assigning students to either Math Lab and/or group study, the researchers felt that it was important for the students to choose the support option that was the best fit for their learning style, work ethic, and schedule. If students utilizing group study felt that they needed additional support, they were able to also utilize the Math Lab in addition to their assigned study groups. Students who selected Math Lab were not given the option to use group study as additional support

unless those students wanted to permanently change their support option. Both group study and Math Lab were intended to aid in course understanding, homework completion, test preparedness, and academic success.

Math Lab

The Math Lab is a self-starter environment where Math Lab leaders monitor learning activities. Students work independently during Math Lab with the option of obtaining assistance from Math Lab leaders on an as-needed basis. Math Lab requires two hours of attendance per week that can be completed at the students' convenience in half-hour increments. Math Lab attendance is monitored by Math Lab Leaders who check students' identification cards and have students sign in and out to document attendance. Math Lab students who maintain perfect attendance throughout the semester are rewarded with a 110% Math Lab grade, which is a portion of their overall course grade. The bonus grade for perfect attendance was excluded during data analysis.

Group Study

Group Study support consisted of a collaborative group that included between three and five students. Group study required two hours of attendance per week. Students completed these hours in one block of time, which was pre-scheduled and remained consistent throughout the semester. Students who selected group study as their support option self-selected their groups and study time. Group study students met in the same building as the Math Lab students but were assigned to designated group areas within the lab space. Group study participants monitored and self-reported their attendance to their professor using a Group Attendance and Accountability Log (Appendix C). The groups were assigned a Graduate Assistant Academic Coach who helped the group begin their work, assisted in maintaining the group atmosphere, and acted as a mentor throughout the semester. If the group required assistance in mathematics, the Math Lab leaders were available for support.

Students participating in group study were rewarded according to their group averages on exams. If a group's exam

average was an A, then three bonus points were added to each group member's exam grade. If the group's average was a B, then each member of the group was awarded two points to their exam grade, and if the group's average was a C, each group member was awarded one point to their exam grade. No points were awarded for a D and below. Any bonus points awarded for this purpose were omitted during data analysis.

This method of rewarding group study students based on the average exam grade earned by their group was selected as both a motivational tool and an accountability tool. The researchers wanted students to invest in each of their group members and use their knowledge to help each other develop their mathematical knowledge. The researchers were hopeful that students would collaborate and engage with the course material through communication and discussion, thereby developing their own and each other's understanding.

Group Study Facilitation

Each group participating in a group study was assigned a Graduate Assistant Academic Coach. The graduate assistant was responsible for managing each group and disseminating information relevant to their studies, such as upcoming quizzes or exams. During the first group meeting, the graduate assistant conducted an icebreaker activity to help group members become comfortable working together. The graduate assistant also reviewed the group study policies in detail (Appendix B) and explained how to use the Group Attendance and Accountability Log (Appendix C). The graduate assistant was also responsible for giving each group member the Study Strategies handout and explaining each strategy (Appendix D). Finally, the graduate assistant facilitated the group in creating their own group rules during the first meeting.

For the second through fourth group study meetings, the graduate assistant simply checked in at the beginning of the meeting to facilitate group activity and followed up later in the meeting to assess the group's progress. During the fifth group meeting, all groups were given the Group Participation Rubric (Alfred State College of Technology, 2003), which was designed to assess their

work as well as the work of every group member (Appendix E). After the fifth week, the graduate assistant only facilitated the group on an as-needed basis.

All groups participating in group study completed the Group Attendance and Accountability Log for each study session. The Group Attendance and Accountability Logs were reviewed by the course instructor. As one underlying objective was to develop independent collaborative learners, each group's use of the recommended Study Strategies (Appendix D) was not monitored beyond what the groups reported on their log. In addition to documenting homework completion, the logs allowed groups to identify which of the following strategies were used during their study sessions: brain dumps, "types" of problems, homework review, and practice quizzes/exams (see Appendix D for a detailed explanation of these strategies). No formal work was collected or assessed beyond the group's log.

Method

Setting of the Study

This study occurred at a public four-year institution in the northeastern United States. The institution serves approximately 8,000 undergraduate students. Introductory Algebra and Intermediate Algebra are developmental mathematics courses housed in a centralized department of developmental instruction. At the time of the study, the centralized department of developmental instruction coordinated and administered two levels of developmental mathematics, reading, and writing, as well as tutoring and academic advising. Enrollments in the higher-level developmental courses are capped at 25 students per section while the lower-level courses are capped at 20 students per section. The courses are taught for either three days per week for 50 minutes or two days per week for 75 minutes.

This study was conducted over a spring and fall semester in the same calendar year. Data was collected in three sections of Intermediate Algebra during the spring semester. During fall, data was collected in one section of Introductory Algebra and two sections of Intermediate Algebra. The same professor, who is

one of the researchers, taught all courses. Student demographic information was not collected during the study. Additional attributes such as high school GPA, placement exam scores, and SAT scores were not available to the researchers.

Participants

Enrollment in both Introductory Algebra and Intermediate Algebra is determined by placement scores (see Table 1). Students who place out of these classes can self-select the course(s) if they feel it necessary.

Table 1

Placement Scores

Course Placement	SAT	ACT	Accuplacer
Introductory Algebra	$x \leq 450$	$x \leq 16$	$x < 60$
Intermediate Algebra	$460 \leq x \leq 500$	$17 \leq x \leq 19$	$60 \leq x < 74$

At the time of the study, all incoming students were administered the Accuplacer test to determine the most appropriate developmental mathematics course; course placement was determined by the highest placement score. For instance, if a students' SAT/ACT score placed them into Intermediate Algebra while the Accuplacer score placed the student into Introductory Algebra, the student was required to complete Intermediate Algebra. Students that placed into Introductory Algebra were required to successfully complete both Introductory Algebra and Intermediate Algebra before they were able to enroll in their credit-bearing course(s) required for their major and/or general education requirements.

This study utilized a purposeful sample of students enrolled in one of the researcher's courses for spring and fall semesters. All students enrolled in either Introductory Algebra or Intermediate Algebra are required to complete two hours of out-of-class support in the Math Lab. During this study, students were given the option of attending Math Lab or participating in group study. All students self-selected their support option based upon personal preferences

and were informed that they could change their support option if they decided that it was not the best fit for them. Students were discouraged from jumping back and forth between Math Lab and group study. There were also students who, for whatever reason, did not attend either Math Lab or group study.

Within this study, all students were classified into either Math Lab, group study, or no support based upon their attendance in each of the support options for the semester. Since all students were required to attend two hours of out-of-class support each week, each student's attendance was calculated based upon the two required hours each week and the number of weeks of support available in the semester. For example, during the fall semester, there were thirteen weeks of support that students were required to attend (no support is available the first week of the semester or finals week). Since there were thirteen weeks of support and each student was required to attend two hours each week, there were twenty-six total hours of support.

For students to be classified into one of the three support options (group study, Math Lab or No Support), they needed to attend more than 50% of that support option for the semester. As an example, one student attended 17 hours of support (group study) out of the 26 required throughout the semester. That student had a 65% attendance rate for group study and was classified into the group study support option. Another student attended 16 hours of group study (62% attendance rate), 4 hours of Math Lab (15% attendance rate), and 6 hours of no attendance (23% attendance rate) in either support option. As a result that student was determined to have primarily utilized group study as his support option.
All students were required to attend a minimum of two hours of out-of-class support each week, but students were welcome to attend more hours if they wanted. Although some students chose to attend more than two hours for the week, those hours were ignored for support calculations since they exceeded the two required hours. Five students did not have more than 50% attendance in any one of the three support options (Math Lab, group study, or no support) and they were not included in the data set. There were 114 students included in the study; 73 students utilized Math Lab, 31 utilized

group study, and 10 students did not utilize any support option. For students to earn the group study bonus points based upon their group's average exam grade, they had to attend their group study sessions for two weeks before the exam.

Instrument

The LASSI was used to determine whether students participating in Math Lab and group study were able to develop improved study behaviors over a semester. Students were asked to take the LASSI during the first two weeks of the semester and again at the end of the 14-week semester. The pre-test and post-test results were compared to determine if there were significant gains in any of the ten areas assessed by the LASSI instrument.

Findings

The findings of this study are framed around the research questions:

1. Do developmental mathematics students who participate in a structured peer study group achieve higher quiz, exam, and course grades when compared to those who do not participate?
2. Do developmental mathematics students who participate in a structured peer study group develop better general study strategies over a semester when compared to those who do not participate?

Research Question 1 (Achieve Higher Grades)

Students were categorized into one of three support group options based upon their attendance throughout the semester: group study (n = 31), Math Lab (n = 73), and no support (n = 10). Average grades were calculated for each participant in each of the following categories: homework, quizzes, each unit exam, final exam, all exams combined, and the overall course grade. A simple comparison of the averages illustrated that the average grade for the group study participants was higher across all categories except exam two and exam four when compared to the students who participated in Math Lab (see Table 2). A comparison of the averages of the students who participated in group study versus those students who did not

utilize any support showed higher averages across all categories except exam four.

Table 2

Average grades across all measures and support options (bonus points not included)

Measure	group study (N=31)	Math Lab (N=73)	No Support (N=10)
HW Average	84.61	84.30	67.00
Quiz Average	78.13	73.63	66.10
Exam 1 Average	78.84	78.45	70.70
Exam 2 Average	72.90	73.59	68.00
Exam 3 Average	73.00	70.85	71.90
Exam 4 Average	70.80	71.86	78.00
Final Exam Average	68.19	63.55	63.70
Average of All Exams	73.19	71.55	68.50
Course Grade Average	75.39	73.27	64.40

Although the averages were higher in seven of nine categories, further investigation using an independent samples t-test did not show significance between students utilizing group study when compared to those students using Math Lab for support in any measure. Significance was found in the average homework grade for students participating in group study ($M = 84.61$) when compared to homework grades of students not using any support ($M = 67.00$), $p = .02$. Independent samples t-test also showed significance on homework grades when students participating in Math Lab ($M = 84.30$) were compared to students not using support ($M = 67.00$), $p = .001$.

Research Question 2 (Development of Study Strategies)

Of the 31 students who participated in study groups, 21 students took both a pre-test and post-test of the LASSI. Of the 73 students who participated in Math Lab, 50 students took both LASSI tests. The students utilizing group study and the students in Math Lab were analyzed separately to determine if there were differences among the groups. The scores were analyzed by comparing the pre-test and post-test scores in an analysis of variance with repeated measures.

Upon analyzing the students who participated in group study,

there were significant differences in the pre-test and post-test raw scores for Information Processing (INP), $p = .003$, and Study Aids (STA) with $p = .014$. However, when analyzing the students who participated in Math Lab, there were no significant differences in any of the ten scales assessed by the LASSI instrument.

Discussion

This study's goal was to determine whether students who participated in a structured group study would achieve higher grades in several categories (homework, quiz, exams, and course grades). Although the averages were higher in seven of nine categories, there were no significant differences between the group study and Math Lab populations in any measure. Group study only significantly affected homework grades when compared to the population utilizing no support. The significantly higher homework grades may have resulted from the students working collaboratively on their homework during their group study session. The collaborative environment likely created an environment of accountability that assisted in homework completion. Significance was also found between Math Lab participants and participants utilizing no support on the homework average. This finding may imply that students are using the mandatory support options as a study hall to complete their work. Since the group with no support had a significantly lower homework average, the data suggests that out of class support (regardless of type) helps developmental mathematics students complete their homework.

While the data shows that group study participants had higher averages in almost all of the categories, the students that did not participate in any type of support for the semester had the highest average on exam four. At this point in the semester, the students earning a B or above in the course were no longer mandated to attend their support option. The researchers question if their achievement decreased on exam 4 because some of them were no longer receiving support.

According to the pre-test and post-test results for the LASSI, there were no significant differences between the results for those students who participated in Math Lab. This suggests that,

although Math Lab may support students in their success in their developmental mathematics course, this form of peer support does not necessarily promote the development of skills transferable to other courses, at least not over one semester.

In the pre-test and post-test comparison of students participating in group study, significant differences were found in both Information Processing and Study Aids. According to the LASSI manual, "the Information Processing Scale assesses how well students can use imagery, verbal elaboration, organization strategies, and reasoning skills as learning strategies to help build bridges between what they already know and what they are trying to learn and remember" (Weinstein & Palmer, 2002). This suggests that students participating in group study were able to further their ability to relate new information to previously learned material, a critical study skill.

The other scale that yielded significant change was the Study Aids Scale. Also, per the LASSI manual, "the Study Aids Scale assesses students' use of supports or resources to help them learn or retain information" (Weinstein & Palmer, 2002). This suggests that students participating in group study were able to further develop their effective use of resources to assist in academic success. Development in both areas over one semester is encouraging since it demonstrates growth in areas that will benefit students in future coursework. The significant movement in these areas among the study group participants is likely the result of more structured interactions with other students allowing them to learn from one another.

Anecdotal Observations

One researcher noted some anecdotal observations she made during classes concerning the students who participated in group study. She observed that these students chose to sit next to each other in class. Not only did group study students sit together, but they also seemed very comfortable asking each other questions during class and seemed to use each other for support. Only when all students were stumped would they seek the instructor out for assistance. Students that chose to utilize Math Lab were more

dependent upon the course instructor. Math Lab students were not as comfortable collaborating with their classmates and using them for assistance.

Limitations

A limitation of this study was the small sample size of students participating in this study. A greater sample size may yield different results in terms of significance and should be explored in further research. There were also some issues with group communication and students not showing up for their group meeting times, which can affect group dynamics and functioning. Snow days were also an issue for the students participating in group study because groups were scheduled to meet for two hours, at a specific time, on a specific day of the week and missing a meeting because of a snow day meant the students missed their scheduled math support for the week. A suggestion for replicated research is to include a make-up policy for students utilizing group study as a method of support.

Another limitation of this study was the departmental policy for developmental mathematics support. At the mid-term point in the semester, students whose grade is a B or above are no longer mandated to attend and utilize support options (they can elect to participate). As long as the student maintains an overall course grade at or above the B level, they are excused from group study or Math Lab from mid-term through the end of the semester. Due to this policy, some students participating in group study were excused at mid-term, which resulted in some groups losing members. Since the groups ranged in size from three to five members, some groups lost a significant number of members. The resulting group had to establish a new culture with the remaining members, which impacted the functionality of the group. For those groups that became too small to operate, students were paired up with other students who lost group members and new groups were formed with remaining members from other groups. The loss at mid-term of the highest academically achieving group members may have affected the results of the study.

Finally, the setting for the study was a public four-year institution located in the northeastern United States. The department where the courses and support options were coordinated are housed in a centralized department of developmental instruction. The conditions, policies, and resources of support at this institution may not necessarily apply or be transferable to other institutions. The results of this study are not generalizable.

Implications for Research and Practice

The results of this study were examined in the context of two semesters, and researchers looked at both academic success in the supported courses and study skill development over a 15-week term. The researchers assumed that students would develop study skills that would contribute to their future academic success; however, a longitudinal analysis would be required to verify that this is indeed a reasonable conclusion.

Additionally, this study focused solely on study groups and their effect on achievement in developmental math. A parallel study in other developmental courses, such as reading and writing, would inform us of the effectiveness of this strategy on developmental students in general. Finally, a comparison of the outcomes of group study for students in college-level courses, either in math or other disciplines, would provide some insight into group study's effects on students performing college-level work.

This study has highlighted the need to further examine the out-of-class support options for developmental mathematics since students utilizing support are not earning significantly higher grades across the selected categories.

Conclusion

In a comparison of a structured group study program and an independent math lab model, the data indicated that students participating in group study had higher averages than students who used Math Lab (although this was not statistically significant), across the following measurements: homework, quizzes, exam 1, exam 3, all exams combined, the final exam, and overall course grades. Additionally, there was statistical significance in the homework grade

of students using group study versus the students who did not receive support and among students who used the Math Lab versus no support. This indicates, as one might expect, that participation in any type of support program yields better academic results than not participating.

In addition to favorable academic results, according to LASSI pre-test / post-test results, group study students scored significantly higher on Information Processing (INP) and Study Aids (STA). This suggests that students in group study were developing the ability to relate new information to old at a significantly higher rate than students in Math Lab or no support. Also, group study students gained the ability to utilize resources to assist in successful course completion. Group study is a valuable support option because it is inexpensive, nonintrusive, and adaptable. Group study also empowers developmental students by strengthening their mathematical study skills, self-directed learning, and accountability by immersing them in a cooperative and collaborative environment.

References

Adams, P., Gearhart, S., Miller, R., & Roberts, A. (2009). The accelerated learning program: Throwing open the gates. *Journal of Basic Writing, 28*(2), 50-67.

Alfred State College of Technology. (2003). *Group Participation Rubric.* Retrieved from http://alfredstate.edu/assessment/GenEd/

Arendale, D. R. (1994). Understanding the Supplemental Instruction model. In D. C. Martin, & D. R. Arendale (Eds.), S*upplemental Instruction: Increasing student achievement and retention.* (New Directions in Teaching and Learning, No. 60, 11-21). San Francisco, CA: Jossey-Bass. http://dx.doi.org/10.1002/tl.37219946004

Baker, D. F. & Campbell, C. M. (2005). When there is strength in numbers. *College Teaching, 53*(1), 14-18.

Copus, C., & McKinney, B. (2016). Early integration of tutorial support in beginning algebra. *Journal of Developmental Education, 40*(1), 32-34.

Daneshamooz, S. & Alamolhodaei, H. (2012). Cooperative learning and academic hardiness on students' mathematical performance with levels of mathematical anxiety. *Educational Research, 3*(3), 270-276.

Deshler, J., Fuller, E., & Darrah, M. (2019). Supporting students through peer mentoring in developmental mathematics. *Learning Assistance Review, 24*(1), 87-112.

Dias, O., Cunningham, A.W., & Porte, L. (2016, February). Supplemental Instruction for Developmental Mathematics: Two-Year Summary. *MathAMATYC Educator, 7*(2), 4-9, 55.

Diehl, T.E. (2017). Development of a Structured Learning Assistance (SLA) Program. *Journal of Developmental Education, 40*(3), 32-34.

Hooker, D. (2011). Small peer-led collaborative learning groups in developmental math classes at a tribal community college. *The Official Journal of the National Association for Multicultural Education, 13*(4), 220-226.

Hurley, M., Jacobs, G., & Gilbert, M. (2006). The basic SI model. In M. E. Stone & G. Jacobs (Eds.), *Supplemental instruction: New visions for empowering student learning*, pp. 11–22. San Francisco: Jossey Bass.

Mireles, S. V., Offer, J., Ward, D. D., & Dochen, C. W. (2011). Incorporating study strategies in developmental mathematics/college algebra. *Journal of Developmental Education, 34*(3), 12-41.

Morales, E. E., Ambrose-Roman, S., & Perez-Maldonado (2016). Transmitting success: Comprehensive peer mentoring for at-risk students in developmental math. *Innovative Higher Education, 41*, 212-135.

Quitadamo, I. J., Brahler, C. J., & Crouch, G. J. (2009). Peer Led Team Learning: A prospective method for increasing critical thinking in undergraduate science courses. *Science Educator, 18*(1), 29-39.

Sandoval-Lucero, E., Blasius, E., Klingsmith, L., & Waite, C. (2012). Student-initiated study groups for STEM classes in community college settings. *Canadian Center of Science and Education, 2*(2), 31-39.

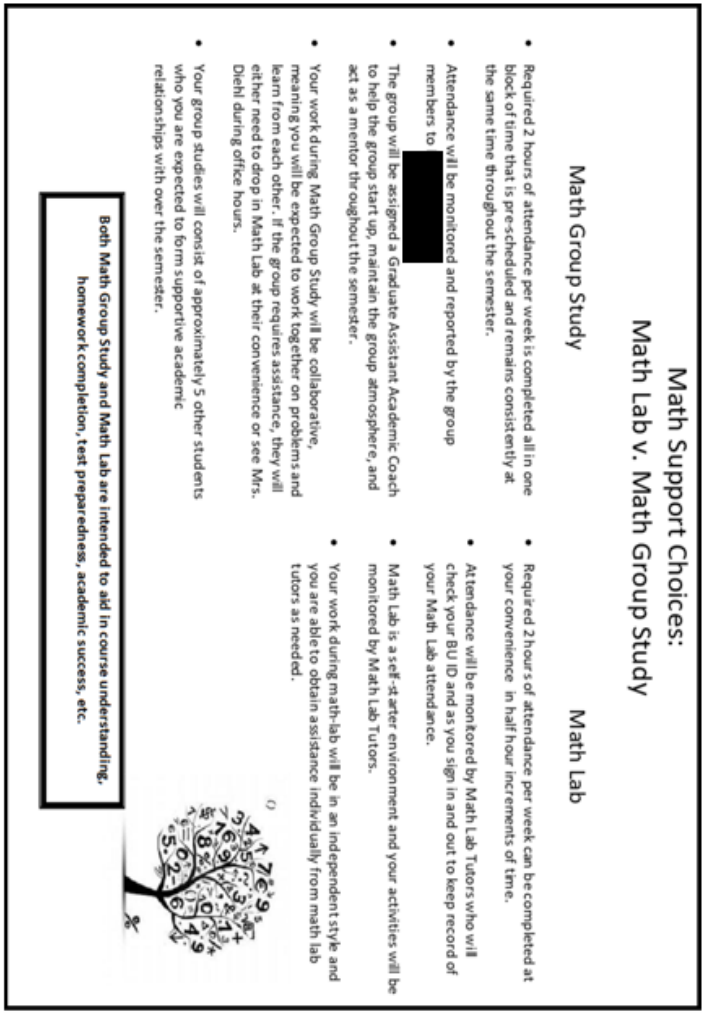
Street, C. D., Koff, R., Fields, H., Kuehne, L., Handlin, L., Getty, M. & Parker, D. R. (2012). Expanding Access to STEM for At-Risk Learners: A new application of universal design for instruction. *Journal of Postsecondary Education and Disability, 25*(4), 363-375.

University College, Ferris State University. (2008). *Facilitator manual training guide, structured learning assistance.* Big Rapids, MI.

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.

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

Appendix A



Appendix B
Math Group Study Policy

Group Study is designed to assist all students in successfully completing their coursework. The collaborative, group atmosphere will offer students the study strategies, background information and practice time vital to academic success. Group Study sessions are an important part of the academic course and, to be beneficial, must be attended with regularity. To that end, the following policies will be in effect for Group Study.

General Attendance and Lab Policies:

1. All students are required to attend their 2-hour session of Group Study each week until mid-term. Students may also choose to attend Math Lab in addition to their Group Study session.

2. Students must attend the entire Group Study session.

3. Students will need to sign in at each study session.

4. At mid-term, students who have earned a grade of 'B' or better in the course are no longer mandated to attend Group Study, however, it is certainly encouraged.

5. Students are required to attend Group Study at any time during the semester in which their grade falls below the established cut-off and until their grade improves up to the minimum score. It is the student's responsibility to learn if he or she is required to continue attending throughout the semester. Students should ask the professor if they are uncertain. Do not make any assumptions about your attendance status.

6. No more than two (2) unexcused absences from the required Group Study sessions will be permitted during the

semester. Absences may not be consecutive Group Study sessions.

7. All students will earn a 100% Group Study grade unless they exceed two absences. Students exceeding two absences from Group Study sessions will be removed from Group Study and are mandated to attend Math Lab immediately. Math Lab grades will be determined based upon the Math Lab Attendance Policy.

8. All Group Study members have the potential to earn extra credit on their exams. If the exam average for all Group Study members is an "A", each Group Study member will receive an additional three points (+3) on each of their exams. A Group Study "B" average will result in an additional two points (+2) and a Group Study "C" average will result in an additional (+1) point.

9. The Group Study policy is separate from the professor's attendance policy. Students are required to understand and follow both policies.

10. Students who are requested to refocus their behavior on the learning task more than two (2) times during a Group Study session may be dismissed and marked absent.

11. A student must have all required materials and actively participate to be counted as having attended a Group Study session. This includes bringing lecture notes and textbooks. A student who comes to the Group Study session unprepared and is not participating will be asked to leave the Group Study session and no credit for attendance will be earned.

12. Students may be dismissed from the Group Study program if they are disruptive, uncooperative, disrespectful to other members, do not participate and/or contribute to the function of the group.

Expectations for Student Participation in Group Study:
• Have all textbooks and learning materials.
• Participate fully and actively in Group Study session activities.
• Have a positive attitude about learning.
• Work collaboratively with other students and respect all views and opinions.
• Appropriately address all group members.
• Work only on material/homework pertaining to Math Group Study.
• Inappropriate language (profanity) and personal misconduct will not be tolerated and will result in dismissal from Group S tudy. Any dismissals will be counted as unexcused absences.

Adapted from:

University College, Ferris State University. (2008). *Facilitator manual training guide, structured learning assistance*. Big Rapids, MI.

Appendix C
Math Group Attendance and Accountability Log

Date and time of study group:

Group Member Attendance:

Print Name	Sign Name
1.	
2.	
3.	
4.	
5.	
6.	

What did your study group accomplish today?

What is your plan for the next study group meeting?

Are there any group questions or concerns for the course instructor?

Appendix D

Math Study Strategies

Strategy	Description
HW Review	Review the previous week's homework as well as the current homework assignment. Focus on all problems that were incorrect, incomplete, or that you struggled with. Re-do those homework problems as necessary. Choose even-numbered problems that look similar to the problems you experienced difficulty with. There are instructor edition textbooks in Math Lab that you can borrow to check your answers to even-numbered problems. Successful and prepared math students do more homework than is assigned and can complete every homework problem without using their notes and the answers in the back of the book. If there are problems that you cannot figure out, seek out assistance (math lab, other students, course instructor) on those problems immediately. The longer you wait the more difficult it will become.
Notes Review	Compare your class notes to other students. Fill in any gaps that you find. Request clarification on anything you did not understand from the notes (math lab, other students, course instructor). Pay careful attention to the "notes" in your notes. They are important and color-coded to attract your attention. Be sure to include the concept maps in this review.
Practice Quizzes/Exams	Create a practice quiz/exam. Since you know the format for quizzes and exams, try to model your practice quiz/exam after the real one. Be thorough as you are creating your practice quiz/exam. Copy the page and problem number down for each problem you use on your practice quiz/exam so you can check your work. Allow some time to pass and then take your practice quiz/exam. Grade yourself and review any

"Types" of Problems	Examine each section of homework and identify "types" of math problems in each section. Review each "type" taking care to determine the qualities, properties, and characteristics of each "type."
For the exam, I must be able to. . .	Write down each section and idea/objective you need to know for your exam. Under each objective write an example of each "type" of problem. Rate yourself (E = excellent, S = satisfactory, N = needs improvement) on each objective. Direct your studying to those objectives that are rated N and S first. If time permits, review any marked E. Think of this strategy as an outline for your exam. Keep this outline. You will find it useful when preparing for your final exam.
Brain Dump	The brain dump paper is created by you before the exam and is one side of an 8 ½ x 11 piece of paper. You can use your brain dump paper during the exam as a sort of "cheat sheet." Feel free to write down anything that you might need to be successful on the exam. You may want to include just examples on your brain dump or a combination of examples and notes to help guide you through the work. Don't forget about all those special "notes" in your class notes. Since you know how the exam is organized, I encourage you to organize your brain dump to correspond with the exam. If you create a practice exam, take it using only your brain dump paper. This will tell you whether your brain dump paper is thorough.

Appendix E
Group Participation Rubric: Math Group Study

Skills	3 Advanced	2 Competent/meets expectations	1 Progressing/does not fully meet expectations	0 Beginning/does not meet minimum expectations
Contributions/participation Attitude	Always willing to help and do more, routinely offered useful ideas. Always displays positive attitude.	Cooperative, usually offered useful ideas. Generally displays positive attitude.	Sometimes cooperative, sometimes offered useful ideas. Rarely displays positive attitude.	Seldom cooperative, rarely offers useful ideas. Is disruptive.
Working with others/cooperation	Did more than others – highly productive Works extremely well with others, never argues	Did their part of the work – cooperative. Works well with others, rarely argues.	Could have done more of the work – has difficulty, requires structure, directions and leadership, sometimes argues.	Did not do any work – does not contribute, does not work well with others, usually argues with teammates.
Focus on task/commitment	Tries to keep people working together. Almost always focused on the task and what needs to be done. Is very self-directed.	Does not cause problems in the group. Focuses on the task and what needs to be done most of the time. Can count on this person.	Sometimes not a good team member. Sometimes focuses on the task and what needs to be done. Must be prodded and reminded to keep on task.	Often is not a good team member. Does not focus on the task and what needs to be done. Lets others do the work.
Preparedness	Brings needed materials to class and is always ready to work.	Almost always brings needed materials to class and is ready to work.	Almost always brings needed materials but sometimes needs to settle down and get to work	Often forgets needed materials or is rarely ready to get to work.

Group Member Names	Contributions (Participation & Attitude)	Working with Others (Cooperation)	Focus on task (Commitment)	Preparedness	POINTS EARNED
1.	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	
2.	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	
3.	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	
4.	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	
5.	3 2 1 0	3 2 1 0	3 2 1 0	3 2 1 0	