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## **AC 2011-243: INITIAL EVALUATION OF THE IMPACT OF MATH STUDY GROUPS ON FIRST-YEAR STUDENT COURSE SUCCESS**

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# INITIAL EVALUATION OF THE IMPACT OF MATH STUDY GROUPS ON FIRST-YEAR STUDENT COURSE SUCCESS

## Abstract

As part of an NSF-funded STEP project, first-year students in engineering and computer science were assigned to small study groups based upon their math course. The groups were facilitated by upper-level undergraduate students, and met weekly through the Fall and Spring semesters of the 2009-10 academic year. While attendance was strongly encouraged, attendance at the study group sessions was not required. In the Fall 2009 semester, study groups were organized around the Intermediate Algebra course, the College Algebra and Trigonometry courses, and the first Calculus course. In the Spring 2010 semester, study groups were added for higher-level Calculus courses. During the study groups, students would work on assigned homework problems as well as additional problems provided by the facilitators. The students worked together to solve the problems, with guidance and some tutoring provided by the facilitators.

In the Fall 2009 semester, attendance in the study groups was approximately 30%. This dropped to 15% in the Spring 2010, which we attribute to students forming their own study groups as well as increased realization among the students that there was no obvious consequence for not attending the groups. Our initial observations of the impact of the study groups include the following: (1) there was a subset of students who were likely to succeed in the course without attending any study group; (2) for the remainder of the students, the students' grades were often higher based upon attending more study group sessions; and (3) the study groups for the College Algebra and Trigonometry courses had the largest impact on students' performance, particularly in the Fall 2009 semester. The results indicate that study groups can be a successful method for improving first-year student learning of math concepts. In turn, this should improve the retention and eventual graduation of the students.

In this paper, the study groups are described in greater detail, and the results of the study groups' impact on student grades are presented. Based on what was learned in the 2009-10 year, some modifications to the study group organization were made to increase their impact. These changes are described in the paper as well.

## Introduction

In the United States today, there is great interest in the education and graduation of more students in the Science, Technology, Engineering, and Mathematics (STEM) disciplines.<sup>1,2</sup> There are two primary tasks that are needed for this goal to be accomplished. First, more students need to be attracted to pursue college-level studies in the STEM fields. Second, once those students are attracted to a STEM field, the colleges and universities must provide an attractive, nurturing environment designed to allow a wide range of students to succeed, while still providing a rigorous education.

The College of Engineering and Applied Science (CEAS) at the University of Wisconsin-Milwaukee (UWM) has generally been able to attract as many students into its engineering and computer science programs as for whom it can provide quality educations. But the graduation rates have been lower than desired. For example, the 6-year graduation rate for Fall 2004 incoming freshmen for the college was 26.3%. Recognizing that this type of rate is an undesirably low graduation rate in that it does not advance students to graduation in these STEM fields and that students who have shown interest in engineering and computer science have failed to achieve their goals, CEAS has sought to improve this through several activities. One of these activities is the creation of study groups for incoming freshman, with these groups being led by a higher-level undergraduate student who also serves as a peer mentor. The use of peer mentors and study groups is not a new concept, and has been shown to be successful elsewhere.<sup>3-7</sup> As we have found that math courses tend to be one of the most difficult hurdles for incoming students to overcome, the study groups focus on the appropriate math courses.

Math is the foundational language for all engineering and computer science applications. A strong basic understanding of Algebra, Trigonometry, and Calculus for all students in CEAS is vital for success in subsequent courses. As part of an NSF-funded STEM Talent Expansion Program (STEP) grant, first-year students in engineering and computer science are assigned to small study groups based upon their math course. The groups meet once a week to assist students in mastering their math coursework. An additional goal of the groups is to create an open environment where peers can discuss engineering and computer science interests and applications. The project is now in its third year. During the first year (2008-09), the program was completely optional and voluntary for the students. Participation in the program was poor, so in 2009-10, students were assigned to specific study groups. While attendance improved, scheduling difficulties and a desire to increase attendance even further has led to the college formally entering study groups into their Fall 2010 and Spring 2011 class listings.

### **Format and Purpose of the Study Groups**

Students worked together to solve appropriate math problems with the guidance and some tutoring provided by peer facilitators; these peer facilitators are upper class students in the college. Study groups aim to develop student confidence in collaborative problem solving skills and teach students during their first year in college how to practice independent problem solving methods. This procedure involves and requires deep thought, time, discussion and risk taking; these are all skills beneficial for careers in engineering and computer science. For this reason, leaders are not to have solution manuals. Facilitators work with students to solve problems methodically while encouraging critical thinking, as opposed to supplying answers to questions. Learning problem solving skills in a group will inevitably raise confidence levels of the students early in their college career. These skills will easily transfer to their independent work and the use of study groups is expected to increase retention and graduation and decrease such detrimental practices as cheating.

## **Study Group Evolution**

### Fall 2008 / Spring 2009

The study group initiative began in Fall 2008, when an upper-level undergraduate engineering student was hired and made available for math coursework help at a central location in the college building. The time and location were advertised throughout the Engineering and Mathematical Sciences (EMS) building. Attendance was minimal and although it was beneficial for the one student, it was clear that the program needed more organization to benefit more CEAS freshmen.

### Fall 2009 / Spring 2010

In Fall 2009 and Spring 2010, all registered CEAS freshmen were assigned to a study group based on their math course. The study groups had to be manually chosen and student schedules were filtered according to math level, time availability and major. Assigned groups varied in size from 6 to 12 students per group. Scheduling conflicts prevented the formation of uniformly-sized study groups. A few student schedules were unlike all others rendering it impossible to assign them to a group. Knowing that the majority of the college freshmen live on or near campus, times were selected with a preference for evening hours after all of the day's classes had ended. Leaders were assigned groups based on openings in their schedules. Classrooms were reserved once per week for 1.5 hour intervals between 6:30 and 10 pm on Mondays, Tuesdays, and Wednesdays. E-mails were sent out to individuals by the program coordinator to convey the study group assignments. E-mail groups were created to ease communication between the leader and the entire group. Most students responded well to the study group formations. Students who had extracurricular scheduling conflicts quickly changed groups with the aid of the program coordinator and their academic advisors. Those students who explained their circumstances describing their inability to attend were dropped from the study group program and re-entered in the Spring semester. Groups were created for the Intermediate Algebra course (Math 105), the combined College Algebra (Math 116) and Trigonometry (Math 117) courses, and the Calculus I course (Math 231).

While attendance was strongly encouraged, it was not required. It became apparent that not all students assigned to groups recognized the benefit of the group. In response to lower attendance, communication with the groups was increased. Leaders were assigned to send weekly e-mails to their groups. With this lowered interest in mind, Spring 2010 study groups were assigned to have double the number of students as it was assumed that many students would not attend. As before, scheduling conflicts prevented scheduling uniformly-sized study groups and groups were combined when possible. Study groups were added for higher-level courses including Calculus II (Math 232) and Differential Equations and study groups for the Intermediate Algebra course was no longer offered, although study groups for the College Algebra, Trigonometry, and Calculus I courses continued.

### Fall 2010

To facilitate scheduling of the study groups, In Fall 2010 semester, a one-credit Introduction to Engineering course was introduced into the schedule of classes. Advisors recommended that all incoming CEAS freshmen register. Eighteen fifty-minute sections were made available on

Mondays, Tuesdays, and Wednesdays at three different times: 9:00-9:50 am, 1:00-1:50 pm, and 6:30-7:20 pm. The sections were designed to concentrate on specific math courses, and students were to register for the appropriate section based on their math course. Five new study group leaders were hired while two leaders remained from the year before to share their experiences and serve as role models for the new hires. Most incoming freshmen registered for the course and since it was a part of their schedule, the majority attended throughout the semester. Having the class as a part of their weekly schedule appears to have increased attendance.

### Leader Preparation

The student facilitators were hired and trained according to two *Peer-Led Team Learning* books: *A Guidebook*,<sup>6</sup> and *A Handbook for Team Leaders*.<sup>7</sup> Leaders are taught that peer-led learning can be more effective than the traditional lecture format of college courses. Leaders were hired based on willingness to help, openness to the lecture-free format of the study groups, and success of having earned a 2.7 or higher in their own College Algebra, Trigonometry, and Calculus classes. The main duty of leaders is to keep students working toward a solution to the problem under consideration and to keep them focused during discussions. Leaders are taught to think of themselves as a coach or role model rather than a teacher and to instill the idea that hard work will help the students succeed in their math courses. This is further reinforced in the students because the leader's presence alone proves success in the college is possible. As role models, leaders are expected to represent the school and are not to be spreading rumors or talking poorly of professors, classes, or the college. Since peer leaders are in direct contact with students, leaders can be the difference between success and failure of the students as they enter the college. They are in a position to inspire students and are encouraged to engage students in complex engineering discussions, engineering career paths, design projects, or current events. As another part of training, leaders are also given advice on how to handle different personalities and learning styles and there is a discussion about how different learning styles may be the cause of misunderstandings and frustration. Leaders are given a list of sample questions and ice breaking statements that come from the Workshop Project books.<sup>6,7</sup>

Leaders are required to prepare at least one hour per week for their groups. Leaders are assigned two or three study groups and are given the syllabus of the courses for which they will be peer facilitators. Copies of the College Algebra, Trigonometry, and Calculus textbooks are available for use by the leaders in a central location which is accessible to the leaders at all times. This enables leaders to prepare for their groups and to identify any areas which they perceive may be trouble areas for the students. Leaders are encouraged to work out some problems to be sure that they understand the topics covered. All leaders meet once a week with the program coordinator to discuss group attendance, participation, and any concerns or problems with their groups. This is a time for the leaders to share with each other the progress of their groups and to give each other encouragement and advice. As an example of the interaction that occurs at these meetings, at one meeting the leaders mentioned that students in Intermediate Algebra felt that the material was too easy to justify a study group. The program coordinator suggested creating worksheets to change the format of the material in order to keep students on task. One leader then created a worksheet and brought feedback to the other leaders responding that it was well worth her time. Creating a five question worksheet proved to be easy preparation for her and created a challenging objective for the group. The results showed the students in her group their

weaknesses in a format different from the in-class tests and verified that they did indeed need to study and that attendance in the study group is worthwhile.

### **Study Group Logistics**

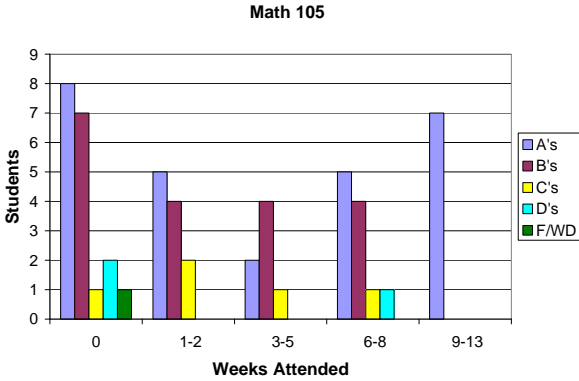
Students arrive at study groups to find that the leader has organized the seating in the room to be in a horseshoe shape with all chairs and desks facing the white board. The leader should be seated as if s/he is a part of the group. The leader facilitates collaborative group work by opening communication and asking about problem areas from the lecture or homework. In the case of a large group or a group with students from several different course sections studying different chapters of the book, the leader will help break the group into smaller more appropriate groups. The leader projects equality with the group through body language alone, such as by sitting among the group members. Once a problem is stated, the group leader will open up the discussion of the solution to the whole group. Students begin to work on the problem which is often chosen from their assigned homework problems. In the beginning, students may need assistance finding procedures to solve problems in the textbook, at which point leaders will use some tutoring skills. As the semester progresses and the students gain experience, students will decrease their reliance on leaders to facilitate and will be able to function as a working study group on their own.

### **Impact of the Study Groups**

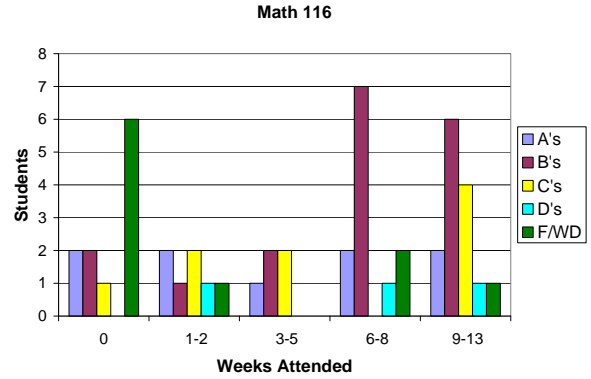
The math course grades of the students were correlated versus frequency of study group attendance for both the Fall 2009 and Spring 2010 semesters, and separated by courses. Study group attendance was broken into 5 categories: frequent (9 or more out of 13 study groups attended), regular (6-8), infrequent (3-5), minimal (1-2), and none (0). Grades were divided by range: "A" consists of all A and A- grades, "B" consists of all B+, B, and B- grades, "C" and "D" are similar to the "B" designation, and "F/WD" contains all grades of F and mid-semester withdrawals from the course. These were done to avoid having the data parsed into groups too small for reasonable analysis. Even with this breakdown, it is clear that data from future years are needed before definitive conclusions on the effectiveness of the study groups can be drawn. Furthermore, secondary future impacts such as improved retention and graduation of students due to their being more quickly integrated into a community of students or from improved study skills will only be able to be judged after several more years.

Figures 1-4 show the grade distributions for the Fall 2009 semester from students in the study groups for Math 105, Math 116, Math 117, and Math 231. Note, the incoming freshmen students in Math 231 tend to be the best in the college, while students in Math 105 are often the worst. Even still, nearly all of the students in Math 105 in CEAS have had the course material in high school and often find Math 105 rather trivial.

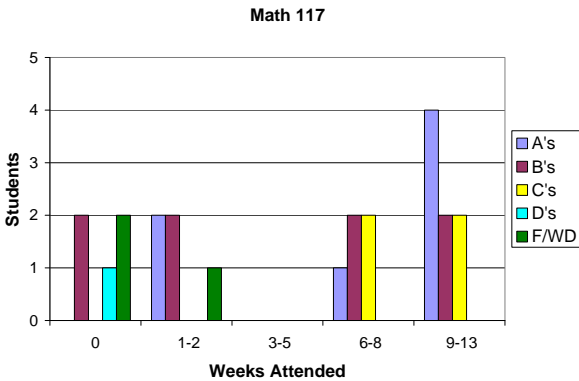
First considering Math 105, in Fig. 1, it can be seen that there were a substantial number of students who did not need study groups to succeed in the course. But beyond those students, there is a trend of improved performance as study group attendance increased. The trends for enhanced performance with increased study group performance are more evident in Math 116 and Math 117 (Figs. 2 and 3). Math 116 is a course which tends to give many students at UWM



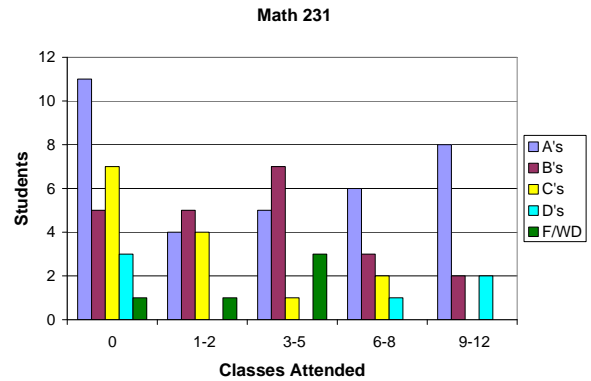
**Figure 1:** Student grades from Math 105 in the Fall 2009 semester, based upon weeks attended in study group sessions.



**Figure 2:** Student grades from Math 116 in the Fall 2009 semester, based upon weeks attended in study group sessions.

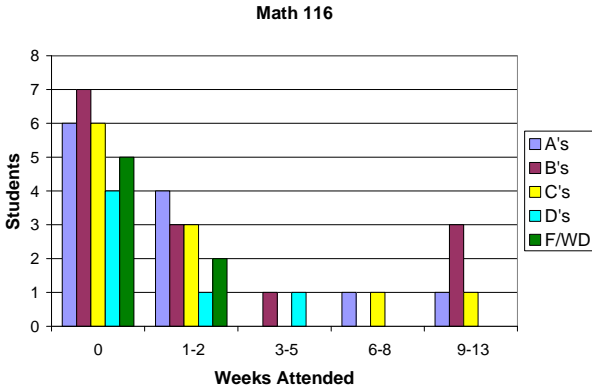


**Figure 3:** Student grades from Math 117 in the Fall 2009 semester, based upon weeks attended in study group sessions.

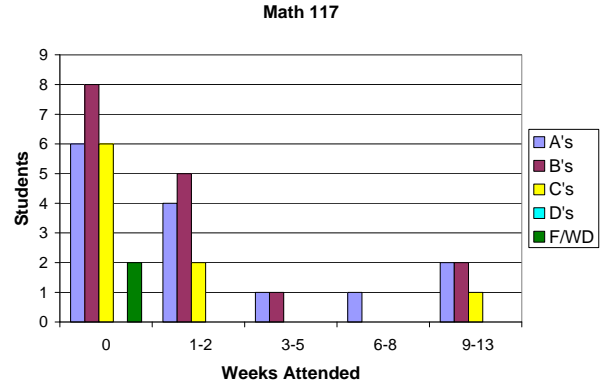


**Figure 4:** Student grades from Math 231 in the Fall 2009 semester, based upon weeks attended in study group sessions.

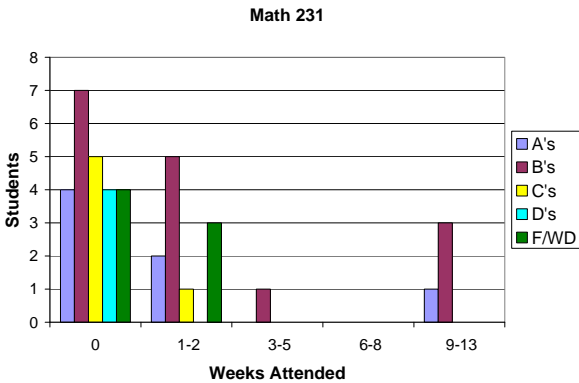
problems, as evidenced by an overall GPA of 1.84 by all students taking the course during the Fall 2009 semester. As can be seen, the student grades in Math 116 were clearly higher for students attending many study groups, while most of the grades of F/WD were earned by students who attended no study groups. Similarly, the majority of grades in the A and B ranges in Math 117 were earned by students who attended 6 or more of the study group sessions (the “regular” and “frequent” attendees). The results from Math 231 (Fig. 4) were less clear. Again, there appears to be a group of students who succeed without formal study groups. Beyond that, there is a trend of increasing frequency of grades in the A range with increased study group attendance, an increase and then decrease in B grades, but also a persistence of poor grades, albeit at a much lower frequency than the good grades. However, the shift in grades from B- and C-range grades to A-range grades with increased attendance is a positive trend.



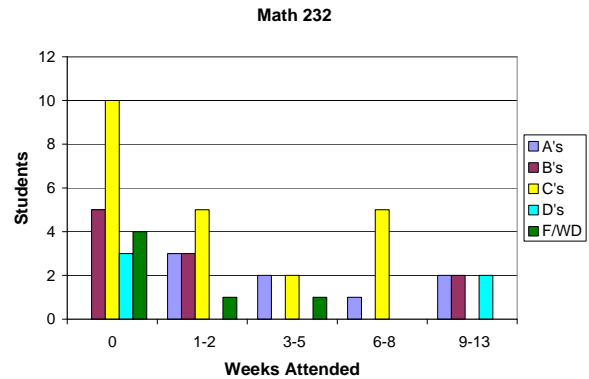
**Figure 5:** Student grades from Math 116 in the Spring 2010 semester, based upon weeks attended in study group sessions.



**Figure 6:** Student grades from Math 117 in the Spring 2010 semester, based upon weeks attended in study group sessions.



**Figure 7:** Student grades from Math 231 in the Spring 2010 semester, based upon weeks attended in study group sessions.



**Figure 8:** Student grades from Math 232 in the Spring 2010 semester, based upon weeks attended in study group sessions.

The analysis of the data from the Spring 2010 semester is complicated by the decrease in the number of students who attended the study groups. The decrease was expected, as it is likely that students began to set up their own study networks during their first semester. Figures 5-8 show the grade results from the Math 116, Math 117, Math 231, and Math 232 study groups. As can be seen, each class had more students not attending study groups than attending the groups.

Because of the small sample sizes of students who attended the study groups regularly or frequently, it is difficult to ascertain a great impact of the study groups on student performance. However, it can be noted that for all four classes in the Spring 2010 semester, nearly all of the grades in the D or F ranges came from students who did not attend or who minimally attended study groups. Students who attended 2 or fewer study group sessions received 25 grades in the D and F ranges, while only 4 grades in those ranges were earned by students attending 3 or more study groups. This suggests that either the study groups do help, or that students were not aware



of their own deficiencies. Considering that most of the poor grades were in Math 116 and Math 117, and therefore were generally earned by students coming from Math 105, this latter scenario is very plausible. Overall, though, this provides information that can be used to educate students, particularly those beginning their studies in Math 105, on the importance of developing good study skills and taking full advantage of the opportunities offered to them.

## **Summary and Conclusions**

Study group attendance has drastically increased yearly from Fall 2008/Spring 2009 to the Fall 2010 semester. A chain of weekly communication that brings opinions and messages from students to leaders to the program coordinator enables changes in the program that allow its improvement every week and semester. Anonymous feedback from both attending and non-attending students is also obtained through the use of an end-of-semester survey containing questions regarding meeting time preferences, feelings toward group efficiency, leader effectiveness, and ideas for improvement. Overall, feedback has described that personal connections with freshmen peers and upper class students, and the engagement in complex conversations are some of the main reasons for attendance in non-mandatory study groups.

The preliminary study of the impact of study groups on student grades indicate that study groups do help the majority of students, although there will always be a group of students who will succeed in their courses without additional outside assistance. Results from the Spring 2010 semester provided information that can be used to stress the importance of study groups for future cohorts of students. Overall, additional data are needed from future years to help in quantifying the benefits of study groups with an enlarged data set.

## **Acknowledgments**

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