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THE IMPACT OF GROUP WORK ENHANCED LEARNING MODEL IN HIGHER MATHEMATICS EDUCATION

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Abstract
Most learning models have been relied on students' individual studying activities. In those models, the efficiency of learning varies among different students, and thusis limited. In this paper, we propose a systematic group study model to improve the learning efficiency for diversity students. By using instructed in-class and out-of-class group work, the group study model has the advantages to overcome the shortages of the individual study modelsand can improve the study efficiency for diversity students. Furthermore, in this model, students can learn from the group as well as from the instructors, thus the teaching performance can be improved. In experimental results, we use statistical analysis to show the improvement of teaching performance and study efficiency for the proposed group study model.
Keywords: Group Study model, diversity students, in-class and out-of-class group work.

1. Introduction

In recent years, with the rise of economic uncertainty and increasing unemployment rates, university enrollment has been on the upswing. Unfortunately, many students (nearly 40%) are unprepared for the college-level mathematics courses required for a degree(Boylan, 2011). Although many courses typically have prerequisite courses designed to ensure that students possess the necessary knowledge and skills to be successful in a higher-level course, not all students meet prerequisite skill levels. Since some students took prerequisites long time ago, or students transfer their courses from a previous institution, the lacking ofrequired content or rigor could affect a student's success in those courses(Ciampa & Revels, 2013). Levin and Koski et al(Levin & Koski, 1998)proposed identity ingredients to be central for designing successful interventions for underprepared students in higher education. These essential ingredients clearly focus on enforcing underprepared students' academic and social growth by means of individual and group works.

In addition, the student population in higher education is much more diverse than that in previous years (Gurin, Dey, Hurtado, & Gurin, 2002; Levin & Calcagno, 2008). Whether or not diversity benefits the group performancestill remains a debatable topic.Dreifus and Hong (Dreifus, 2008; Hong & Page, 2004)proposed that diversity among a group of problem solvers is more important than individual.In their experiments, diverse groups of problem solvers outperformed the groups of the best individuals at solving problems. The reason is that the diverse groups got stuck less often compared to the smart individuals, who tended to think similarly. They furtherprovided an abstract proof to show that collections of diverse agents can locate optimal solutions to difficult problems, even if agents' abilities are bounded. While, in Page's book (Page, 2008), he explained why difference beats out homogeneityinthat identity-diverse groups in particular have a mixed record, sometimes performing better than homogenous groups and sometimes worse.In this study, students flexibly choose their group members(families, classmates, tutors and others), they may start to work in a diverse group and go along with it; or they may choose to change to a homogeneous group thatmake them feel more comfortable. In this way, most students would be able to search and join a suitable, productive group and maintain a long term cooperation relationship with their team members.In addition, working in a well-functioning group may avoid knowledge-sharing errors (Edmondson, 1996; Gupta, 2012; Hollingshead, Brandon, Yoon, & Gupta, 2011). In a well-functioning group, co-workers have a close personal relationship which may rely on one another or information, advice and help; co-workers may arrange their group problem solving tasks in a group-organizable, group-adaptive and group-repairable way; co-workers are rewarded based on overall team performance rather than on each member's individual contribution.

It's generally accepted that group study is more effective than individual study (Bonwell & Eison, 1991; Springer, Stanne, & Donovan, 1999).Group theorists have espoused multiple benefitsof participating in a group as a member including: empathizingwith future group members, enhancing leadership abilities, experiencingthe power of group, and promoting self-awareness (Corey, 2011; Klein, 2003; Yalom & Leszcz, 2008). The discussion of class participation and its assessment is broadened by the work of Vandrick et al(Vandrick, 2000), noting thatclass participation requires students to speak in class by asking and answering questions, making comments and participating in discussions.

In a traditional learning-studying process, students work on their studies individually. Even though sometimes they go for help, they struggle on their own most of the time. Although a necessary process, individual study limits how students digest the knowledge and how much they can achieve their studying goals. While, during group study process, students can not only learn knowledge and skills but also borrow learning method from each other; difficult problems can be divided into relatively simple sub-problems and conquered by the team members; eventually more results will come out by the team work. Thus, students will learn more and obtain stronger confidence in their studies when they achieve more in their group studies. Furthermore, it will be easier for an instructor to detect common errors and representative problems by seeing thefeedback from the group work, and the teaching quality can be improved based on these correspondents.

Several group study strategies have been discussed in(Barton, 1995; Brown & Palincsar, 1989; Chan, 2012; Pilkington, Bennett, & Vaughan, 2000; Rajan & Marcus, 2009; R. Rohfeld & Hiemstra, 1995; R. W. Rohfeld & Hiemstra, 1994). In (Barton, 1995; Rajan & Marcus, 2009), effective classroom discussion techniques are proposed to create interactive learning atmosphere for students. In(Brown & Palincsar, 1989; R. W. Rohfeld & Hiemstra, 1994), the instructors' roles in group discussion are discussed to further promote learner participation. In (Chan, 2012; Pilkington et al., 2000), an evaluation is conducted on how the use of information and communication technology can support group discussion and flexible learning. However, there is a lack of systematic study on these strategies from Science Educators, and very little research testing this argument has appeared in educational journals.

In this paper, we propose a systematic group study model and evaluate the teaching performance using statistical analysis to demonstrate the successful application of the proposed model.

2. Group Study Model

A group study is a collection of individuals who cooperate on the same tasks via various ways to obtain their individual goals. In this model, the people who participate in the group discussion are not limited to the students or the instructors. Students are encouraged to search for any kinds of resources such as their supervisors, relatives, or tutors. That is, to meet their individual study goal, if necessary, students need to work with any available cooperators.This is especially important to those students who couldn't get sufficient support from their group members and instructors.

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Several strategies are conducted in the group study model through the students consistently participating in and out of class group studies. For students, their activities may include reporting in-class group discussion results, submitting out-of-class group assignments, giving in-class presentations, and working on related research topics. For instructors, their activities may include organizing and attending group discussions, assessing, implementing, and improving group work performance. It's very important that an instructor need to attend student's group discussion. It not only helps instructor to get instant feedback and provide immediate instructions, but also encourages the attendance of the out-of-class group homework discussions.

Figure 1 shows the pathways of the multi-way communication among an instructor, the students, and other potential participants in a group study model. In this illustration, a group consists of 2 to 4 members (no more than 4 members are allowed in a group). The black double-arrowed lines indicate the feedbacks and instructions between instructors and the students. The black double-arrowed lines indicate interactions among groups. Different colors of the group members represent different groups of participants. For example, in doing out-of-class group assignments or research, three students with green colors are in the same group. However, during in-class group discussion or presentation, these three students may select to join different groups. As you can see in our example, two "green" students are still in the same group during in-class discussion but the third "green" student has selected to partner with another "red" student. This means participants can select to join different groups during different phases of group studies.

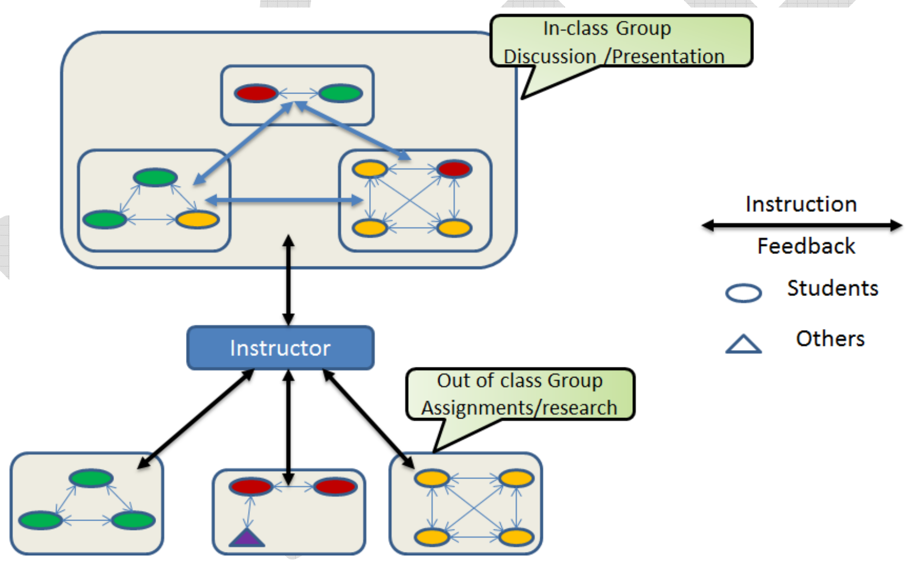


Figure 1. The pathways of the multi-way communication among participants in a group study model.

Aswe know that the traditional teaching methodsencourage one-way communication.Therefore, students are placed in a passive role and the instructorhas difficulties inobtaining instant feedbacks, especially verbal feedbacks.Group study model can help overcome the disadvantages of such traditional teaching methods. For example, during the in-class studies, students constitute small groups with 2 to 4 people in each group and do the group discussions refer to the new learning, followed by a whole class discussion from all the groups by comparing and accessing results with other groups(see interactions among groups in Fig 1). In this way, students have the opportunities to actively study their new knowledge and develop learning skills. At the same time the instructor can get an integrated and representative feedback from all the students and give niche targeting instructions.Last but not least, instructor and students can also have one-to-one communications during the group work.

Learning in a group can fulfill the diverse needs from diverse student audiences.Group study model makes the class offered as a combination of instructor lead and self-paced study process(Schoen, 1976). Generally, students can find suitable group members and become co-learners in discovering what work the best for them individually and as a group. For the students who either have trouble following instructor's lecture, or have no problem grasping the main points of the lecture, they can enhance their understanding on the new knowledge and correct the misunderstanding of their old knowledge by attending group discussions.For students who want to develop their leadership ability, they can act as managers during their group discussions. By working with people of the same or different backgrounds and the same or different study goals, the same questions can be observed from different views and the group study results are more productive than individual study results.

Group study model improves teaching and learning performance. To improve the quality of group study model, the complementary strategies should be used in the same class. For example, in-class discussions may occupy a significant amount of lecture time;students who couldn't digest the new knowledge well would have trouble to be involved into the in-class discussions; there are only limited comprehensive and advanced questions which are fit for individual homework. For However, these shortcomings can be overcome by adopting effective group discussion techniques (Barton, 1995; Rajan & Marcus, 2009; R. Rohfeld & Hiemstra, 1995) and by the extended out-of class homework discussions. In the teaching-learning process, the more the learners are involved, the better they will learn. The in-class group studies can be extended into out-of-class studies. For out-of-class group studies, students are assigned with suitable group homework questions, presentation tasks, or research projects. By this method, the teaching-learning process has been extended beyond the classroom. Furthermore, some students set up long-term co-learner relationship such that they can not only actively work on assigned group work but also be self-motivated on other group work such as group reviews before tests. Figure 2 shows the survey results about group homework on students' understanding and grades assigned at the last day of the college algebra class.According to the survey results, the group homework has positive effects on those who are actively involved in the group discussions; for those who are merely involved in the group discussions, the effects are limited or unclear. This is why it is important for the instructors to attend student's group discussions to promote students' involvement in the group discussions.

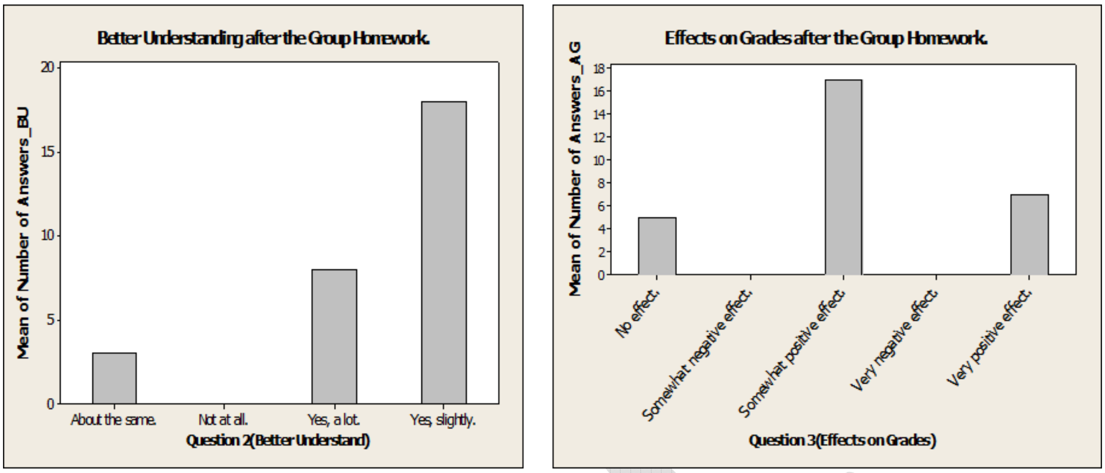


Figure 2.The effects of group homework on students' understanding and grades. Data resource: "Survey on Group Assignment-College Algebra".

3. Experimental Methods and Quantitative Results

The Randomized Controlled Trial (RCT) (Clearinghouse, 2008; Puma, Olsen, Bell, & Price, 2009; Torgerson & Torgerson, 2003) method is widely used in the areas of educational research, particularly in effectiveness research. In this method, participants are assigned to study groups at random and procedures are controlled to ensure that all participants in all study groups are treated the same except for the factor that is unique to their group. The unique factor is the type of intervention they receive. The primary goal of conducting an RCT is to test whether an intervention works by comparing it to a control condition, usually either no intervention or an alternative intervention.

Students are randomly assigned as Before-Treatment students (BF)as the control group, and after-treatment students (AF). In the following, AF students are those who are required to do in-class group discussionand finish their group homework; BF students are those who are required to finish all of their homework problems individually. To maximize validity and minimize bias(Bernstein, Rappaport, Olsho, Hunt, & Levin, 2009; Graham, 2009), the instructor designs and publishes course plan at the beginning of each semester when the students and the instructor have limited knowledge of each other's. In this way, a performed double blind study (Pope Jr, Hudson, Jonas, & Yurgelun-Todd, 1983) could ensure the random assignment. To ensure that all participants in all study groups are treated the same except for the factor(group work) that is unique to their group, the following steps are applied:

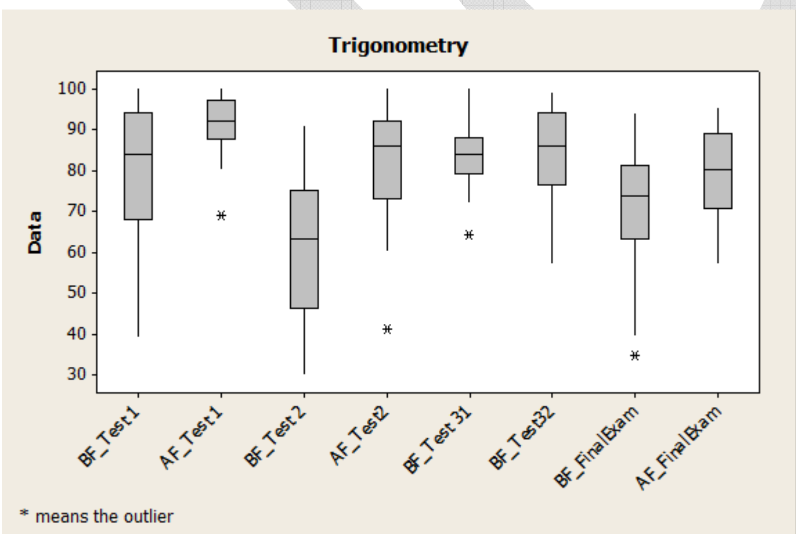
- Step 1,the instructor converts partial lecturing contents into in-class group discussion topics;
- Step2,the instructor converts or implements some individual homework questions into group homework questions and assign regular classes forstudents to finish their group homework.
- Step 3, to encouragestudents in participating the group homework, a group work assessment rubric(http://ed.fnal.gov/trc_new/rubrics/group.html)is provided to and used optionally by students.The grades of these participants are compared to those in the control group to determine if the treatment has an effect on teaching and learning performance.

3.1 Grade comparison between AF students and BF students for Trigonometry

In one Trigonometry class, studentsare required to finish all their homework individually. This class is used as control group. In the other Trigonometry class, students are required to do in-class discussions related to instructor's lectures and finish a portion of their homework in a group before takingthe midterm testsand the final exam, except for midterm test 3. This class is used as experimental group. Both classes have more than 20 participants. The textbook, lecture notes, assigned homework questions,and exam questionsare identical for both classes. Students from the experimental group work on the lecture questions with in-class discussions; and they use regular class time to finish one of their out-of-class homework questions and earn credits; the students in a group will get the same grades for the group homework. On the other hand, students from the control group obtain explanations from the instructor on all the lecture questions.To better compare the results, for midterm test 3, both groups use the same individual study strategy without using group study model.

Figure 3 shows the grade comparisons from all the exams between the experimental group and the control group respectively. The analysis is conducted using the Minitab (Meyer & Krueger, 2001) statistical analysis tool. The comparison shows that the AF medians/means of midterm test 1, midterm test 2 and final exam are significantly higher than those of BF. The differences between the two groups in mean values are significant ($p<0.05$). Also there are substantially variances in experimental groups. Outliers appear in control groups and disappear in experimental group after test 3.

There exists an inconsistent result for midterm test 3 grades ($p>0.05$ shown in red color in Figure 3). This is because there is no assigned group homework before the test for the experimental group. This result again shows strong evidence that doing group problems in and out-of class can improve students' grades.



$$H_0: \mu_{BF} = \mu_{AF}$$
$$H_1: \mu_{BF} \neq \mu_{AF}$$

Test Names	P-value
Test 1	0.006
Test 2	0.000
Test 3	0.966
Final Test	0.073

Figure 3. Comparison of student grades between the experimental group and the control group. Left: grade comparison charts; Right: p-values for each of the midterm tests and final exam. BF_Test31 and BF_Test32 represent the grades from the two groups for test 3 without using group study model.

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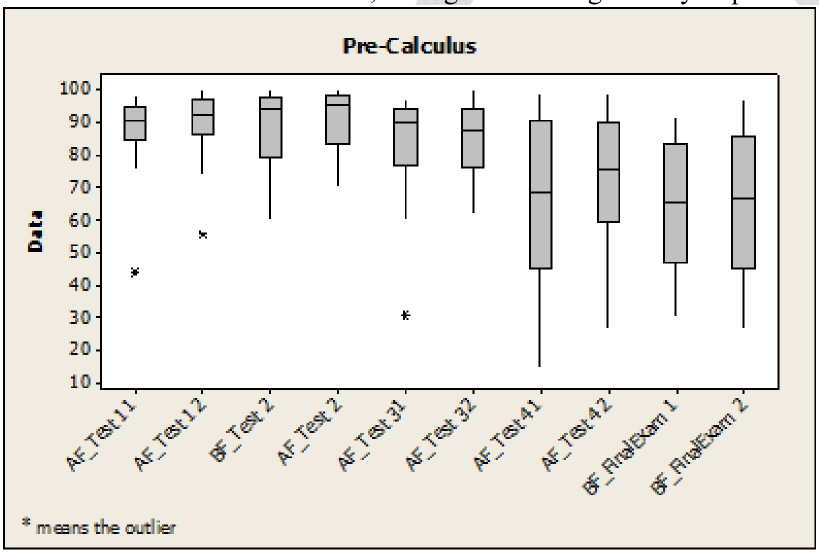
3.2 Grade comparison between AF students and BF students for Pre-Calculus

This experiment is designed as follows. All classes have more than 20 participants. In Spring 2010 Pre-Calculus class, in-class discussions and three out-of-class group assignments are carried out before the midterm test 1, test 3, and test 4; no group study is used before test 2 and final exam. In Fall 2011 Pre-Calculus class, in-class discussion and out-of-class group assignments are carried out before all the tests except final exam. Also enhanced online individual homework is assigned except the hand in individual homework. Figure 4 shows the grade comparison from all the exams between the two classes respectively. The analysis is carried out using the Minitab tool.

Figure 4 shows that the AF median/ mean of midterm test 2 in Fall 2011 is higher than that of BF in Spring 2010. For the rest, the differences between the two semesters grades in mean values are not significant ($p>0.5$). This is due to that the same study model is used for both classes before those tests except for midterm test 2. Outliers disappear after test 3 in both classes.

In Fall 2012, in-class discussion and out-of-class group assignments are carried out before and after all of tests after test 1. From the grades of the first three tests, the level of Fall 2012 students were below those of the students in Fall 2011. However, as students work together after test 1 in groups throughout the rest of the semester in Fall 2012, their grades were generally improved and exceeded those in Fall 2011.



$H_1: \mu_{BF} \neq \mu_{AF}$
$H_0: \mu_{BF} = \mu_{AF}$

Test Names	P-value
Test 1	0.532
Test 2	0.325
Test 3	0.699
Test 4	0.588
Final Test	0.986

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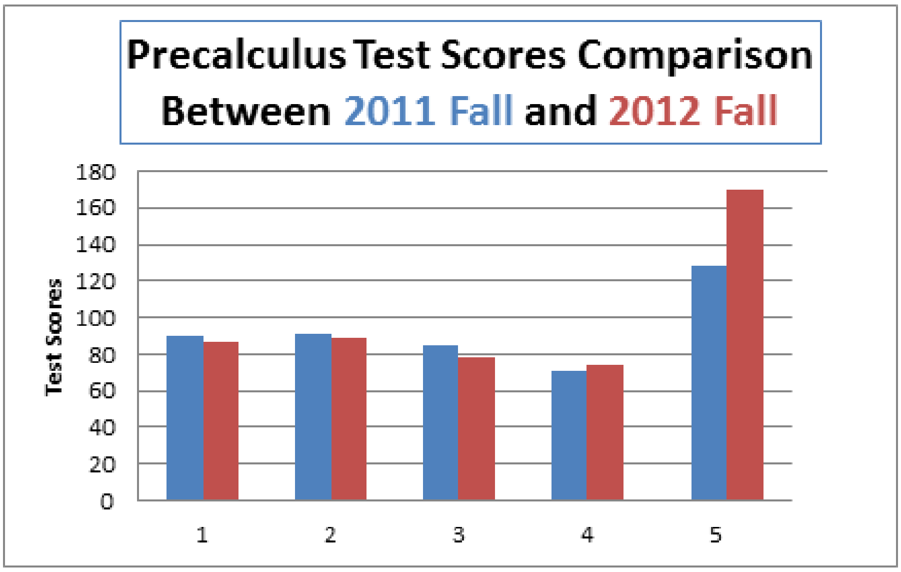
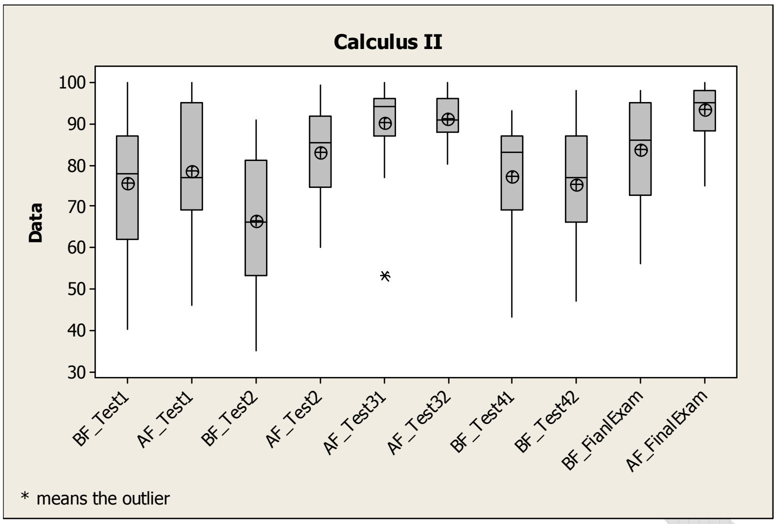


Figure 4.Comparison of student grades for all exams between two Pre-Calculus classes in Spring 2010 and Fall 2011, respectively. Top-Left: grade comparison charts; Top-Right: p-values for each of the midterm tests and final exam. AF_Test11 and AF_Test12 represent the grades from the two groups for test 1 using group study model. Bottom:Comparison of student grades for all exams between two Pre-Calculus classes in Fall 2011 and Fall 2012, respectively.

3.3 Grade comparison between AF and BF for Calculus Class

In this experiment, we compare the students' grades of two Calculus II classes in Fall 2009 and Fall 2012 respectively. Both classes have more than 19 participants. In Calculus II class of Fall 2009, the group homework is used for test 3 only. In Calculus II class of Fall 2012, in-class discussion and out-of-class group assignments are carried out before all the tests except test 4. Figure 5 shows the comparison of student grades for all exams between the two classes. From the grades of test 3 and 4, the level of Fall2012 students were below those of the students in Fall 2009. From the comparison it is clear to see the improvements of grades of the AF students over the BF students, for test 1, 2, and final exam. All variances of the experimental group are less than those in the control group.

$$H_0: \mu_{BF} = \mu_{AF}$$



$H_1: \mu_{BF} \neq \mu_{AF}$

Test Names	P-value
Test 1	0.519
Test 2	0
Test 3	0.643
Test 4	0.692
Final Test	0.003

Figure 5. Comparison of student grades for all exams between two Calculus II classes. Left: grade comparison charts with mean symbols; Right: p-values for each of the midterm tests and final exam. AF_Test31 and AF_Test32 represent the grades from the two groups for test 3 using group study model. The same labeling method is used for other grades.

3.4 Grade comparison between AF and BF for Probability Class

In this experiment, we use a probability and statistics class with 10 enrollments. 9 of them do their research projects in small groups (3 people in each group). One student selects to work on his own for the project. In two of three groups, students have the same majors and it is relatively easy for them to find a common interesting research topic to work on and yield productive results. For example, one group publishes their work in an undergraduate research journal at the end of the project. In the group whose students have different majors, they have hard time determining a research topic. Even though finally they could find a topic and finish it on time, theyshow less interests on their work compared to the other two groups. The student who works on his own has no problem finding a research topic and has strong desire to finish the project. However, the student needs to work on all the details by himself and needs more help from the instructor. Apparently his research work takes much longer time comparedto others. This experiment shows that group work is more efficient than individual work. Aproper combination of group members can perform their work more efficiently and creatively.

4. Conclusions

In this work, we demonstrate that the undergraduate mathematics education in a group setting is more effective than thatin an individual setting. Data analysis shows: 1. In addition to the in-class group works, the out of class group homework play an important role in the proposed group study model. 2, Instructed group work can not only facilitate the process of students group work, but also favor instructor's improvement by offering more targeting instructions.Group study model uses a student-oriented interactive teaching and learning method. This allows students to take active roles in their studies, encourages multi-way communications, helps instructors work more effectively and equitably with diverse students, enriches the learning for students with diverse needs, and improves studying effectiveness compared to individual study models.

5. Future Research

Future studies are needed in order to improve the attendance of out-of–class homework, since not every student couldbe effectively involvedin all group studies due to personality, time conflicts, or other reasons. Further research will focus oninvestigatingthe relationship between students'performance in the experimental group with their degree of participation. Other research may includeimproving individual student's group working skills to make the group work more productive.

References

Barton, J. (1995). Conducting effective classroom discussions. *Journal of Reading, 38*(5), 346-350.

Bernstein, L., Rappaport, C. D., Olsho, L., Hunt, D., & Levin, M. (2009). Impact Evaluation of the US Department of Education's Student Mentoring Program. Final Report. NCEE 2009-4047. *National Center for Education Evaluation and Regional Assistance*.

Bonwell, C. C., & Eison, J. A. (1991). *Active learning: Creating excitement in the classroom*: School of Education and Human Development, George Washington University Washington, DC.

Boylan, H. R. (2011). Improving Success in Developmental Mathematics: An Interview with Paul Nolting. *Journal of Developmental Education, 34*(3), 20-27.

Brown, A. L., & Palincsar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. *Knowing, learning, and instruction: Essays in honor of Robert Glaser*, 393-451.

Chan, E. S. (2012). AN INNOVATIVE LEARNING APPROACH: INTEGRATE PEER-TO-PEER LEARNING INTO BLENDED LEARNING. *International Journal of Global Education, 1*(1).

Ciampa, M., & Revels, M. (2013). The Effect of Self-Remediation Activities on Undergraduate Student Retention. *Kentucky Journal of Excellence in College Teaching and Learning, 10*(2012), 7.

Clearinghouse, W. W. (2008). WWC procedures and standards handbook. *Washington, DC: Retrieved January, 1*, 2009.

Corey, G. (2011). *Theory & practice of group counseling*: Thomson Brooks/Cole.

Dreifus, C. (2008). In professor's model, diversity= productivity. *New York Times*.

Edmondson, A. C. (1996). Learning from mistakes is easier said than done: Group and organizational influences on the detection and correction of human error. *The Journal of Applied Behavioral Science, 32*(1), 5-28.

Graham, J. W. (2009). Missing data analysis: Making it work in the real world. *Annual review of psychology, 60*, 549-576.

Gupta, N. (2012). Team responses to noncontributing members: The effects of attribution and knowledge overlap. *Group Dynamics: Theory, Research, and Practice, 16*(3), 172.

Gurin, P., Dey, E. L., Hurtado, S., & Gurin, G. (2002). Diversity and higher education: Theory and impact on educational outcomes. *Harvard Educational Review, 72*(3), 330-367.

Hollingshead, A. B., Brandon, D. P., Yoon, K., & Gupta, N. (2011). Communication and Knowledge-sharing Errors in Groups. *Communication and Organizational Knowledge*, 133-150.

Hong, L., & Page, S. E. (2004). Groups of diverse problem solvers can outperform groups of high-ability problem solvers. *Proceedings of the National Academy of Sciences of the United States of America, 101*(46), 16385-16389.

Klein, P. D. (2003). Rethinking the multiplicity of cognitive resources and curricular representations: alternatives to'learning styles' and'multiple intelligences'. *Journal of Curriculum Studies, 35*(1), 45-81.

Levin, H. M., & Calcagno, J. C. (2008). Remediation in the Community College An Evaluator's Perspective. *Community College Review, 35*(3), 181-207.

Levin, H. M., & Koski, W. S. (1998). Administrative approaches to educational productivity. *New Directions for Higher Education, 1998*(103), 9-21.

Meyer, R., & Krueger, D. (2001). *Minitab guide to statistics*: Prentice Hall PTR.

Page, S. E. (2008). *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies (New Edition)*: Princeton University Press.

Pilkington, R., Bennett, C., & Vaughan, S. (2000). An evaluation of computer mediated communication to support group discussion in continuing education. *Educational Technology & Society, 3*(3), 349-360.

Pope Jr, H. G., Hudson, J. I., Jonas, J. M., & Yurgelun-Todd, D. (1983). Bulimia treated with imipramine: a placebo-controlled, double-blind study. *Am J Psychiatry, 140*(5), 554-558.

Puma, M. J., Olsen, R. B., Bell, S. H., & Price, C. (2009). What to Do when Data Are Missing in Group Randomized Controlled Trials. NCEE 2009-0049. *National Center for Education Evaluation and Regional Assistance*.

Rajan, N., & Marcus, L. (2009). Student Attitudes and Learning Outcomes from Process Oriented Guided-Inquiry Learning (POGIL) Strategy in an Introductory Chemistry Course for Non-Science Majors: An Action Research Study. *The Chemical Educator, 14*, 85-93.

Rohfeld, R., & Hiemstra, R. (1995). Moderating discussions in the electronic classroom.
Rohfeld, R. W., & Hiemstra, R. (1994). Moderating discussions in the electronic classroom. *Computer mediated communication and the online classroom, 3*, 91-104.
Schoen, H. L. (1976). Self-paced mathematics instruction: how effective has it been? *The Arithmetic Teacher, 23*(2), 90-96.
Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of educational research, 69*(1), 21-51.
Torgerson, D. J., & Torgerson, C. J. (2003). Avoiding bias in randomised controlled trials in educational research. *The British Journal of Educational Studies, 51*(1), 36-45.
Vandrick, S. (2000). *Language, Culture, Class, Gender, and Class Participation*. Paper presented at the TESOL Annual International Convention, Vancouver, Canada.
Yalom, I. D., & Leszcz, M. (2008). *The Theory and Practice of Group Psychotherapy*: Basic Books.