

# Incorporating Inquiry-Based Class Sessions with Computer Assisted Instruction

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Greater Birmingham Mathematics Partnership  
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# Contributors

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## Where to Get More Information

- <http://www.math.uab.edu/GBMP/>
- <http://gbmp.mspnet.org/index.cfm/>

# Active Learning – Computer: All Pre-Calculus Classes at UAB

- 1/3: One class meeting per week
  - What do we do with this class meeting?
- 2/3: Assigned and self-selected time in Mathematics Learning Lab (MLL)
- Assessment online
  - Attendance (class & lab) (14-21%)
  - 20-30 homework problems per week (7-10%)
  - Weekly quiz (7-10%)
  - Four tests per semester (and final) (60-70%)
- Variety of assistance on computer and in lab

# Computer Assisted Instruction

## ● PROS

- Actively engaged with material
- More time spent on task
- On-demand help in lab
- High tech and high touch

## ● CONS

- Algorithmic learning
- Emphasis on memorization
- Computation rather than thought
- Tenuous connection with Quantitative Literacy

# Audience for Finite Mathematics (MA 110)

- General studies students
- Liberal arts students
- Pre-service elementary teachers
  - Take four 3-credit hour courses
  - MA 110 usually one of them
- Pre-service middle school teachers
  - Required in Mathematical Reasoning track in mathematics major

# Finite Mathematics at UAB

- Base: Computer-assisted instruction
  - Mathematics Learning Lab
  - Online homework, quizzes, tests
- Power:
  - Are lectures needed?
  - Alternatives?
  - Why value inquiry-based group work?
  - What comes from frustration?

# Inquiry-Based Group Work Class Format in MA 110

- Groups of four students are selected at random at the beginning of each class
- Each group is given the same problem for investigation
- Group of Four Rules
- Groups decide upon a solution and explanation
- Individual reports written on group work
- Groups volunteer to share their solution and reasoning with the class

# Why Value Group Work?

- Addresses cons of computer assisted instruction
  - Students construct their own mathematical understanding
  - Emphasis on problem solving, communication, and justification
- Addresses UAB Quantitative Literacy goals
- Ideas inspired by GBMP summer courses
  - Focus on “big” mathematical ideas
  - Expandable tasks
  - Importance of frustration to learning process



# What comes from Frustration?

- Building of self-esteem and productive disposition
- Deeper understanding of content
- Long term retention
- Improved ability to communicate mathematical thinking
- Improved problem-solving abilities

We see all this in the GBMP summer courses for in-service teachers.

# Class Simulation

- Group work problem
- Sharing
- Individual written report
  - Evaluated by rubric

# Problem

**Andy, Bert, and Connie are farmers. Their neighbor who is also a farmer is retiring next month and wishes to sell her 12 pigs for \$480. Andy, Bert, and Connie can only afford to purchase the pigs if they pool their money. Andy can contribute \$97, Bert can contribute \$210, and Connie can contribute \$173. How many pigs each should Andy, Bert, and Connie get?**

# Challenge

**After all of the money contributed to the purchase is tabulated but before the pigs are distributed, an extra pig is discovered hiding in the pen (a 13th pig). The neighbor decides to just include the extra pig in the \$480 purchase. How many pigs each should Andy, Bert, and Connie get now?**

# Comparative Study, Fall 2008

## MA 110 Class Formats

- Same computer assisted lab instruction
  - Determines 79% of final grade
- Three different treatment groups
  - *Lecture*: Traditional lecture on up-coming material
  - *Quiz/Lecture*: Lecture on up-coming material and weekly in-class short paper & pencil quiz
  - *Group*: Inquiry-based group work with no prior instruction
- Quasi-experimental: random assignment of students to class formats

# Comparative Study Students

- Students register for one of three time slots (Section)
  - 8 AM, 11 AM, 2 PM
- Section split into 3 subsections
  - Students randomly assigned to subsection
- Each subsection at same time slot receives different treatment
- Nine subsections altogether

# Comparative Study Design

- Three instructor/teaching assistant pairs
- Each pair teaches all three time slots
- Each pair implements each treatment

♣	♥	♦
♦	♣	♥
♥	♦	♣

# Comparative Study Measurements

- Content pre-test and post-test
  - Rated blind according to rubric on
    - Problem identification 0-1
    - Problem-solving 0-1-2
    - Explanation 0-1-2
  - Accuracy 0-1
- Inter-rater reliability
  - High on problem identification
  - Moderate on other two dimensions



# Comparative Study Measurements

- Both pre- and post-tests were graded using a pair of 2 raters.
- The tests were blinded prior to grading to assure confidentiality and randomness.
- To measure the inter-rater reliability of our raters, we ran a Cohen's Kappa for each area of grading.
- All of our Kappa scores, ranging from 0.369 to 0.794, were acceptable with one exception (Problem 2 Evidence).

# Comparative Study Measurements

- Mathematics self-efficacy survey
- Course assessments (grades)
- Focus groups at end of semester
- RTOP observations of instructors
  - Reformed Teaching Observation Protocol
- Delayed post-test (one year)

# Comparative Study Grades

- Total number of points out of 1000
  - lab attendance (70 points)
  - online homework (70 points)
  - supervised online quizzes (70 points)
  - supervised online tests (580 points)
  - **class attendance (210 points)**
- Thresholds: A-880, B-750, C-620, D-500

# Comparative Study

## Class Attendance Points

- 14 class meetings
- Attendance points by treatment group
  - *Group Work*: 10 attendance; 5 evaluation of individual report on group work in class
  - *Quiz/Lecture*: 10 attendance; 5 evaluation of quiz
  - *Lecture*: 15 attendance
- Feedback: individual report on group work evaluated using same rubric as pre- and post-test

# Comparative Study

## Hypotheses

- **Hypothesis 1:** Grades will be similar regardless of treatment
- **Hypothesis 2:** Group work treatment will have differentially improved problem-solving ability
- **Hypothesis 3:** Group work treatment will have differentially improved mathematics communication skills

# Comparative Study Hypotheses

- **Hypothesis 4:** Group work treatment will have differentially improved mathematics self-efficacy
- **Hypothesis 5:** Group work treatment will have differentially improved long-term retention

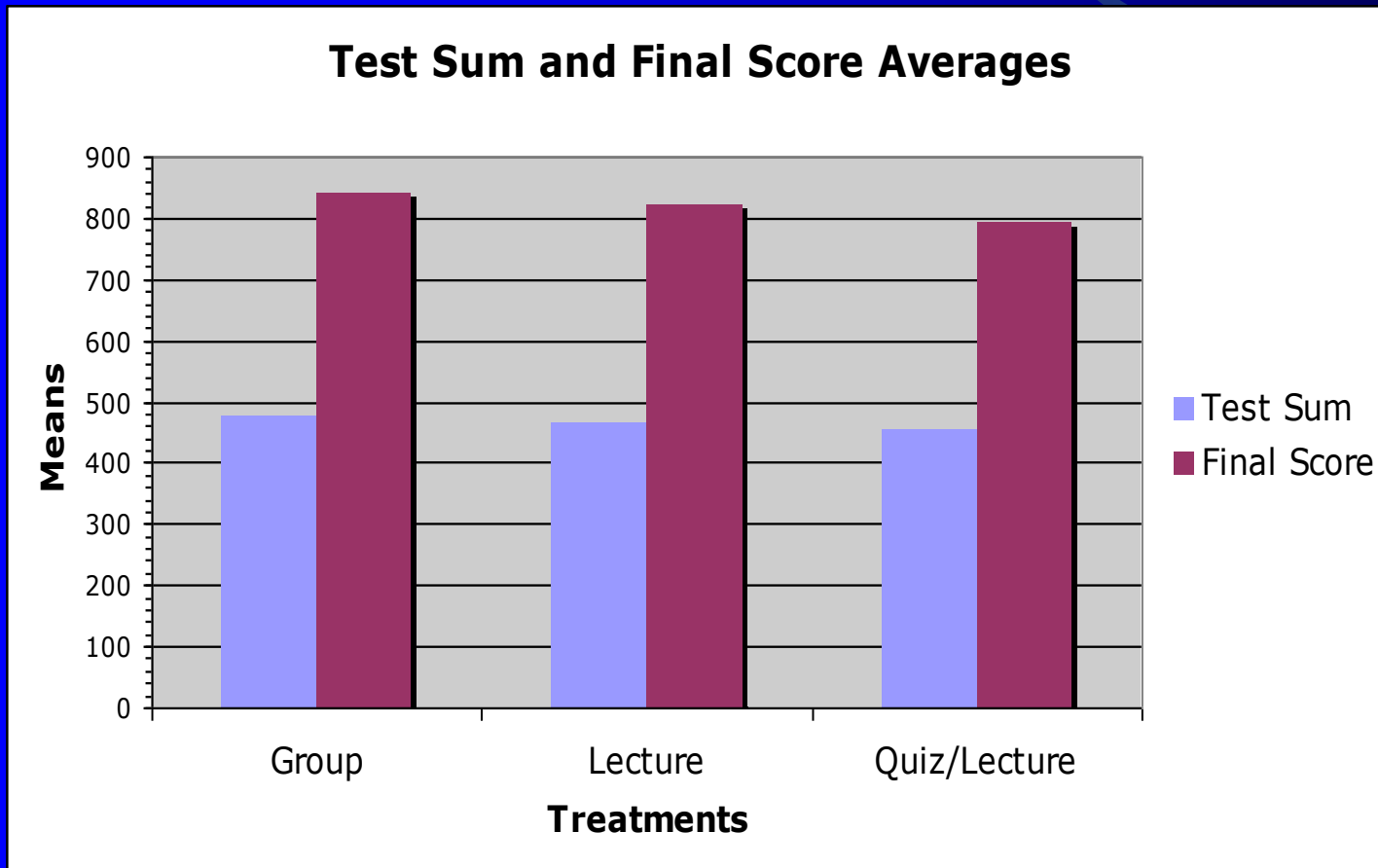
# Summary of Results

- Hypothesis 1 supported:  
no significant difference in grades
- Hypotheses 2 and 3 supported:  
significant differences in favor of  
group treatment on pre-test to post-  
test gains
- Hypothesis 4 not supported:  
no significant differences in  
mathematical self-efficacy

Statistical details to follow ---->

# Data Supporting Hypothesis 1

- All treatments had similar grades for both sum of tests and final scores



Students who withdrew and those who missed at least 2 tests were excluded



# Analysis of Test Sum and Final Score Data

- No significant differences in Final Scores or Test Sums (sum of 4 test scores)
- Test Sum Analysis
  - Between-subjects effects for Treatment, Instructor, and Treatment\*Instructor were not significant at  $p \leq 0.05$  (Scheffe)
  - N=245: Group=80; Lecture=77; Quiz/Lecture=88.
  - Excluded: 39 students withdrew or quit

# Pre-Test and Post-Test

- Three questions
  - Constructed response
- Scored with same rubric used to score individual reports on group work
  - Problem identification: 0 - 1
  - Problem-solving: 0 - 1 - 2
  - Explanation: 0 - 1 - 2
- Accuracy: 0 - 1

# Data Supporting Hypotheses 2 and 3

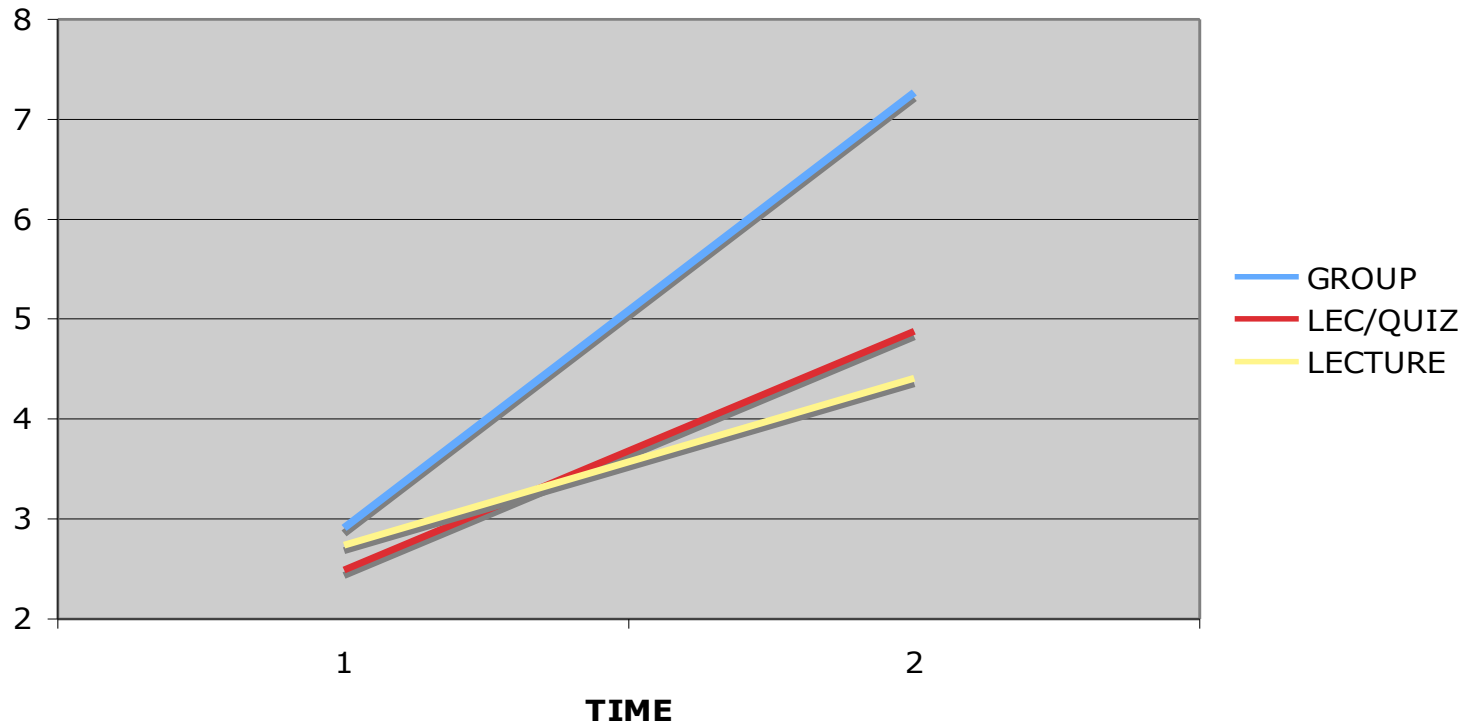
- Group work treatment had largest increase from pre-test to post-test
  - Demonstrated increased communication and problem-solving skills

Means	Pre-Test	Post-Test	Difference
Group	2.93	7.41	4.48
Lecture	2.74	4.32	1.59
Quiz/Lecture	2.47	5.00	2.53

N=214: Group=71; Lecture=68; Quiz/Lecture=75

# Support for Hypotheses 2 and 3

**GROUP \* TIME EST. MARGINAL MEANS**



Only those students who took both the pre-test and post-test were compared

# Analysis of Pre-Test and Post-Test Data

- Repeated Measures ANOVA (Wilks' Lambda) indicated significant differences at  $p < 0.05$
- Time main effect (Pre- to Post-) was significant ( $\lambda = 0.50$ )
- Time\*Treatment interaction effect was significant ( $\lambda = 0.86$ )

# Analysis of Pre-Test and Post-Test Data

- Post-Hoc analysis for Treatment (Bonferroni)
- Univariate analysis of difference scores
- Significant at  $p < 0.05^*$

Treatment	Treatment	Mean Diff	Std Error
GroupWk	Quiz/Lec	1.883*	0.475
GroupWk	Lecture	2.710*	0.485
Quiz/Lec	Lecture	0.826	0.475

# Accuracy Analysis

- Pre- and Post-tests evaluated for accuracy of answers
- Questions 1 and 3 considered
- Significant effect pre- to post- for all treatments taken together
- No significant differences among treatments
- Problems with question 2

# Hypothesis 4 Not Supported

- Survey of Mathematical Self-Efficacy, given pre- and post- was subjected to factor analysis
- 5 factors were evident; 7 (out of 34) questions rejected from analysis
- All treatments showed significant improvement in mathematics self-efficacy
- No significant between-treatments effects overall, nor in any individual factor ( $p < .05$ )



# Limitations

- Problem with question 2 pre- to post-
  - Arguably not equivalent
  - Instructor differences
- Rater training on rubric
  - Only moderate --- 6 raters
- Accuracy on post-test still low (0.33 mean)
- Unit of significance
  - Student versus class
  - Correlation of variance because of a common experience
  - Theory versus practice: supression of differences

# Continuation Study Design

## Spring 2009 MA 110

- Same as group work from previous semester
- Only difference between sections is instructor
- Pre- and post- tests now have four questions rather than three and question two was fixed to be identical on pre- and post-tests.

# Spring 2009 Results

- All classes showed a significant improvement from pre-test to post-test.
  - Demonstrated increased communication and problem solving skills.
  - All three areas (identifying the problem, evidence of problem solving and explaining thinking) showed a significant improvement from pre- to post-test.
- Repeated Measures ANOVA(parametric) and Wilcoxon Signed Ranks Tests(non-parametric) were performed. Both yielded similar results and concludes there was a significant difference from time 1 to time 2.

# Spring 2009 Results

Group Work-ALL Sections	Pre Mean	Post Mean	Difference
Identifying the Problem	0.88	1.53	<b>0.65</b>
Evidence of Problem Solving	3.19	4.77	<b>1.58</b>
Explain your Thinking	1.87	2.69	<b>0.82</b>
Total	5.94	8.99	<b>3.05</b>

# Spring 2009 Results

- Same self efficacy survey and factor analysis as fall semester.
- No significant differences between pre-test and post-test overall or in any specific factor.

# Spring 2009 Results

- Accuracy graded on all questions.
- No partial credit. 1 for correct and 0 for incorrect.
- Significant differences found on all questions but parts b, d and e of question 4.

# Spring 2009 Results

- Question 4
  - New Question
  - No Instruction in Class on Topic
  - Significant improvements found on all 5 parts
  - The only part of the question where there was no significant difference was parts b, d and e of the accuracy analysis.

# Conclusions

- The inclusion of group work class meetings in lieu of lecture does not appear to affect adversely student success as measured by grades
- Inquiry-based group work does have a positive effect on problem-solving and communications abilities



# Conclusions

- Success in a mathematics course increases mathematics self-efficacy among a population taking one of the lowest entry-level courses that carry college credit
- The addition of a weekly paper and pencil quiz to lecture treatment, over and above the regular quizzing done within the computer-assisted instruction, does not affect student performance in terms of grades or problem-solving/communication

# Implications

- Projected study of Basic Algebra in Fall Semester 2009, with two treatments:  
Group and Lecture
  - Many pre-service elementary school teachers start in the non-credit course, Basic Algebra, and take Intermediate Algebra, and Pre-Calculus Algebra, in addition to Finite Mathematics

# Where to Get More Information about GBMP

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- <http://gbmp.mspnet.org/index.cfm/>

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