Inquiry-Based Group Work Improves Student Achievement in Algebra

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Greater Birmingham Mathematics Partnership
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(All statements are the responsibility of the authors, not NSF.)

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Where to Get More Information

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

Audience for Basic Algebra (MA 098)

- Developmental Course (Non-Credit)
- General studies students
- Liberal arts students
- Pre-service elementary teachers
  - Take four 3-credit hour courses
  - Sometimes must take MA 098 first

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

Comparative Study, Fall 2009 MA 098 Class Formats

- Same computer assisted lab instruction
  - Determines 80% of final grade
- One class meeting per week outside lab
- Two different treatment groups
  - *Lecture:* Traditional lecture on up-coming material
  - *Group:* Inquiry-based collaborative group work with no prior instruction
- **Quasi-experimental**
  random assignment of students to class formats

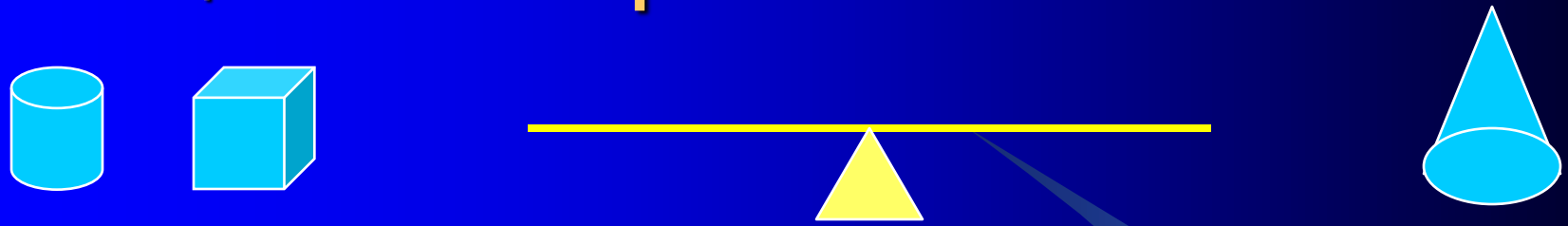
Examples of Problems

- Typical group work problem
  - –About 4th week of class
  - –*Groups of Four*, randomly assigned for this class session

Group Work Directions

- Discuss these problems in your group.
- Come up with a way of understanding and solving each of the problems.
- Provide a written account of your understanding.
- Consider volunteering to present your work to the class, when asked.

Example 1: Group Work Problem



- **Problem:** Suppose that two cylinders balance three cubes on a scale, and one cone balances two cubes on the same scale. How many cylinders would it take to balance 6 cones on this scale?
- **Challenge:** Using the information given above, how many cylinders would it take to balance 351 cones? How many cylinders would it take to balance "*n*" cones?

Example 2: Problems Compared

- Group Work
- Workbook
- Online

Group Work Problem

- A truck travels 260 miles through a flatland route in the same amount of time that it travels through a 160-mile mountainous route. The rate of the truck is 20 miles per hour slower in the mountains than in the flatland. Find the rate of the truck on the flat route and on the mountain route.

Workbook Problem

5.6 Example 7: A truck travels 120 miles on the highway in the same amount of time it takes to travel 40 miles in the city. If the rate that the truck is traveling in the city is 30 miles per hour slower than on the highway, find the rates at which the truck was traveling both on the highway and in the city.

	Distance	Rate
Highway	120	R
City	40	R – 30

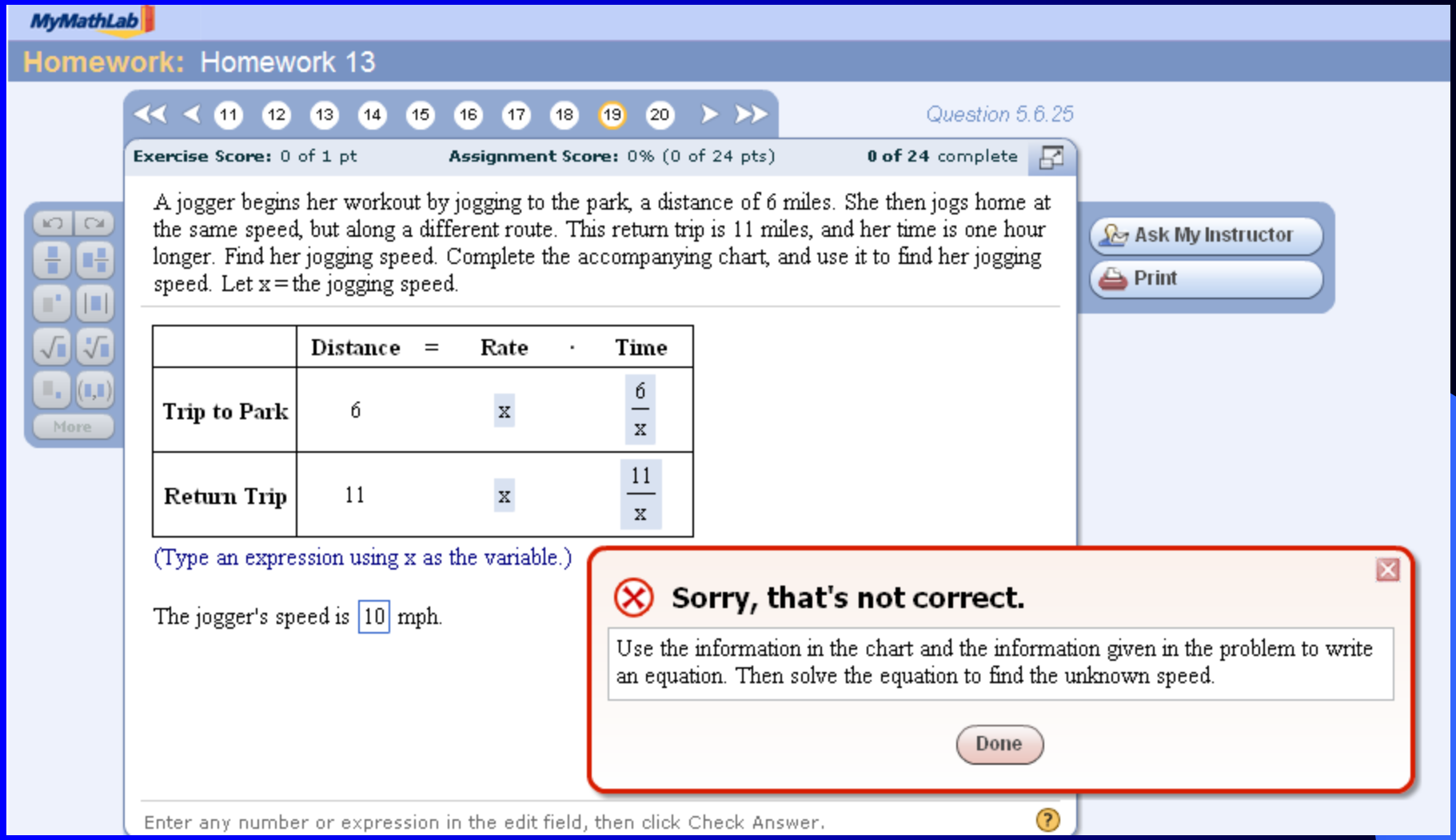
Since the times are equal, we can solve this by setting the ratios equal to each other (a proportion.)

$$\frac{120}{R} = \frac{40}{R-30}$$

$$120(R-30) = 40R$$
$$120R - 3600 = 40R$$
$$120R - 40R = 3600$$
$$80R = 3600$$
$$R = 45$$

The truck is traveling 45 mph on the highway and 15 miles per hour in the city.

Online Problem

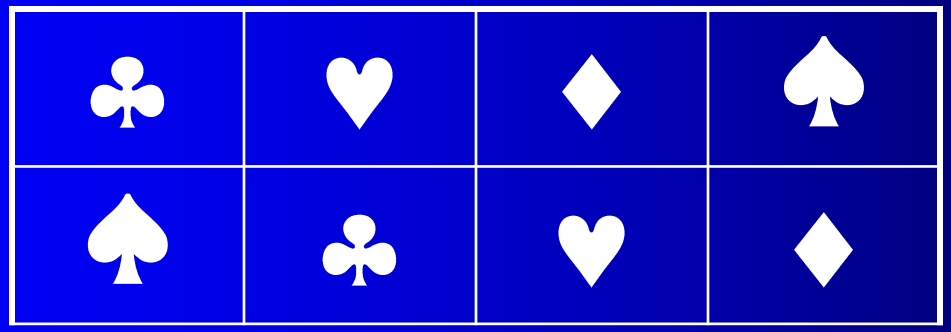


Comparative Study Experimental Design

- Students register for one of four time slots
  - 9 AM - MW, 9 AM - TT, 10 AM - TT, 12 Noon - MW
- Section split into 2 subsections
  - Students randomly assigned to subsection
- The two subsections in the same time slot receive different treatments
  - Lecture or collaborative group work

Comparative Study Experimental Design

- Four instructor/teaching assistant pairs
- Each pair teaches two time slots
- Each pair implements each treatment



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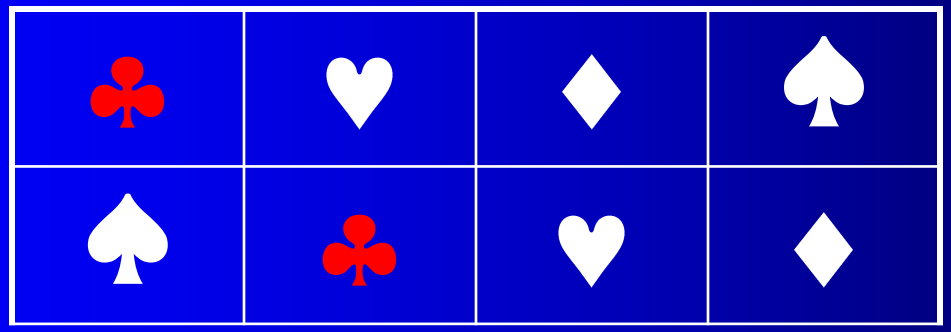


Comparative Study Measurements

- 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
  - Inter-rater reliability moderate
  - Accuracy scale 0-10
- Course assessments (grades)
  - Sum of first four of five tests.

Comparative Study Hypotheses

- Hypothesis 1: Grades will be similar regardless of treatment (as measured by computerized test sum)
- Hypothesis 2: Group work treatment will have differentially improved problem-solving and communication skills (as measured by rubric)

Summary of Results

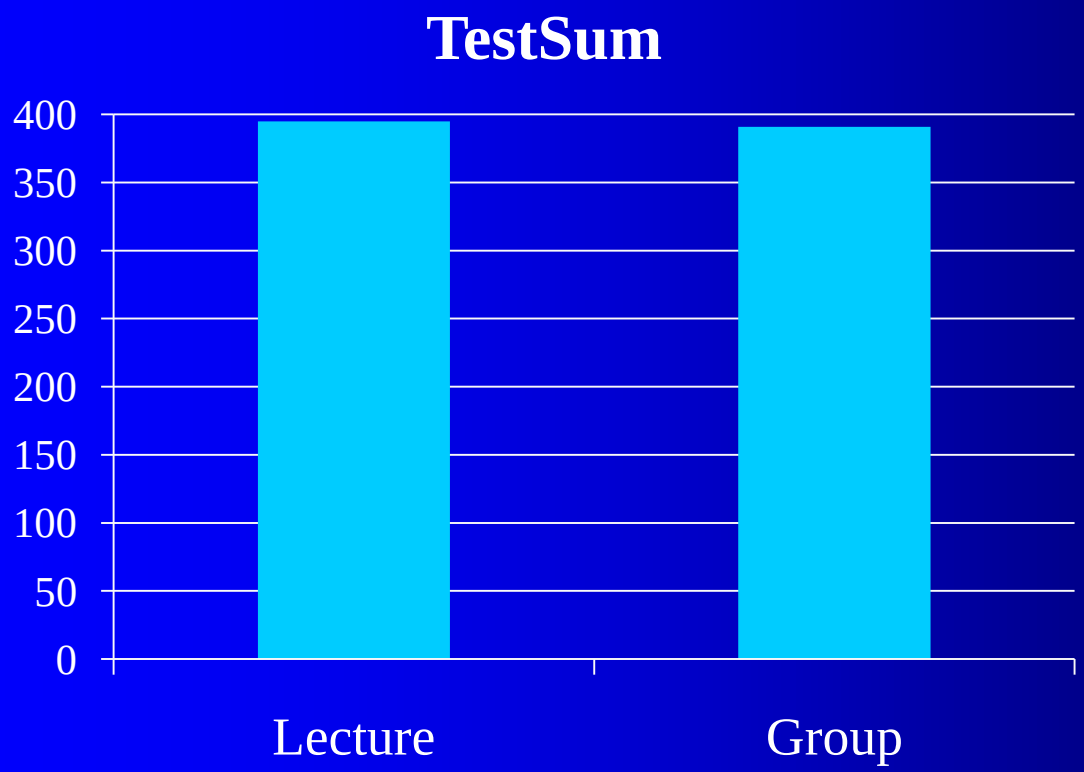
- Hypothesis 1 supported:
  no significant difference in test grades

- Hypotheses 2 supported:
  significant differences in favor of group treatment on pre-test to post-test gains

Statistical details to follow ---->

Data Supporting Hypothesis 1

- All treatments had similar grades for sum of first four (of five) tests

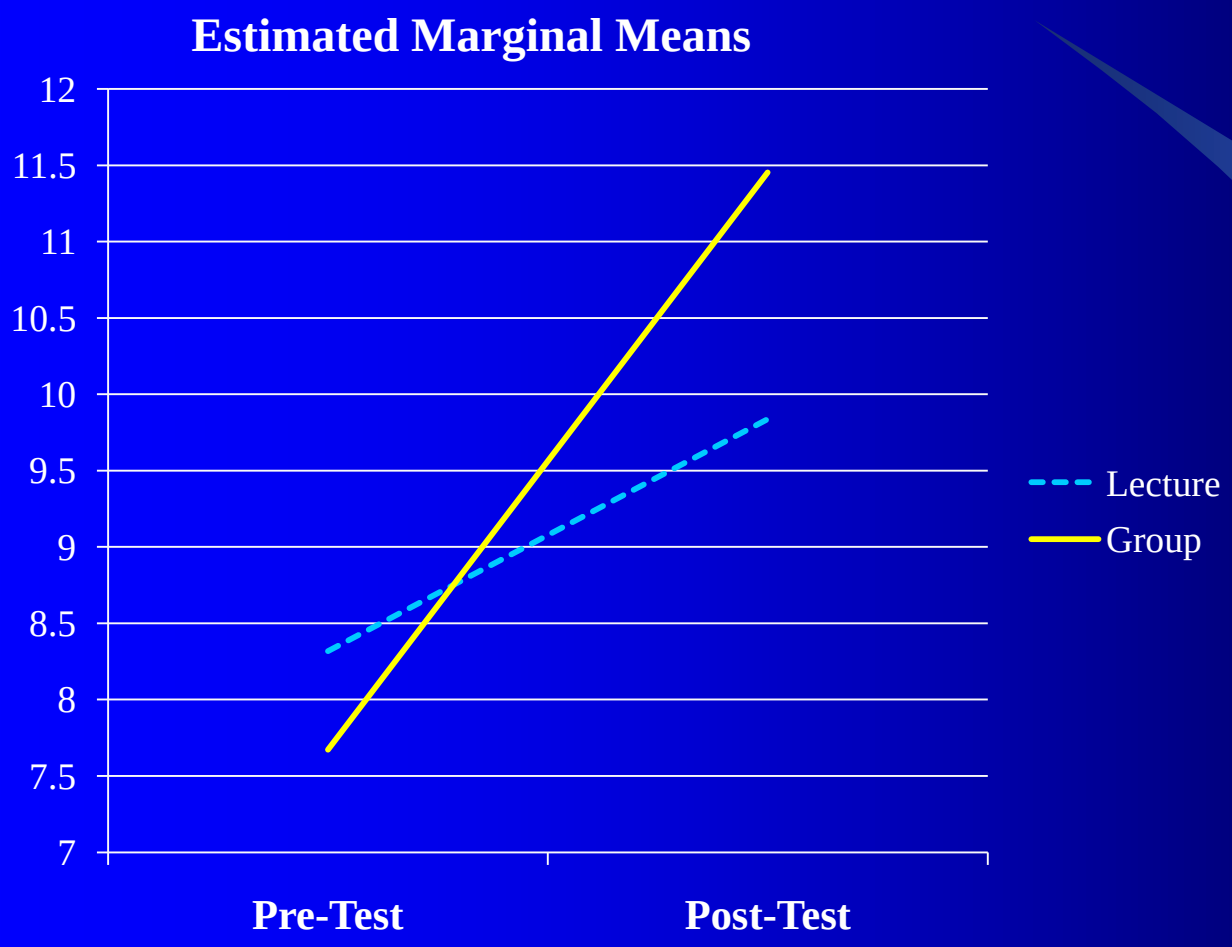


N=300
Lecture=149
Group=151
No significant differences ($p<0.05$) on sum of tests, or any single test.

Pre-Test and Post-Test

- Four questions
  - 3 constructed response
  - 1 multiple choice with explanation
- 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 scale 0 – 10
  - Some questions had multiple parts

Support for Hypothesis 2



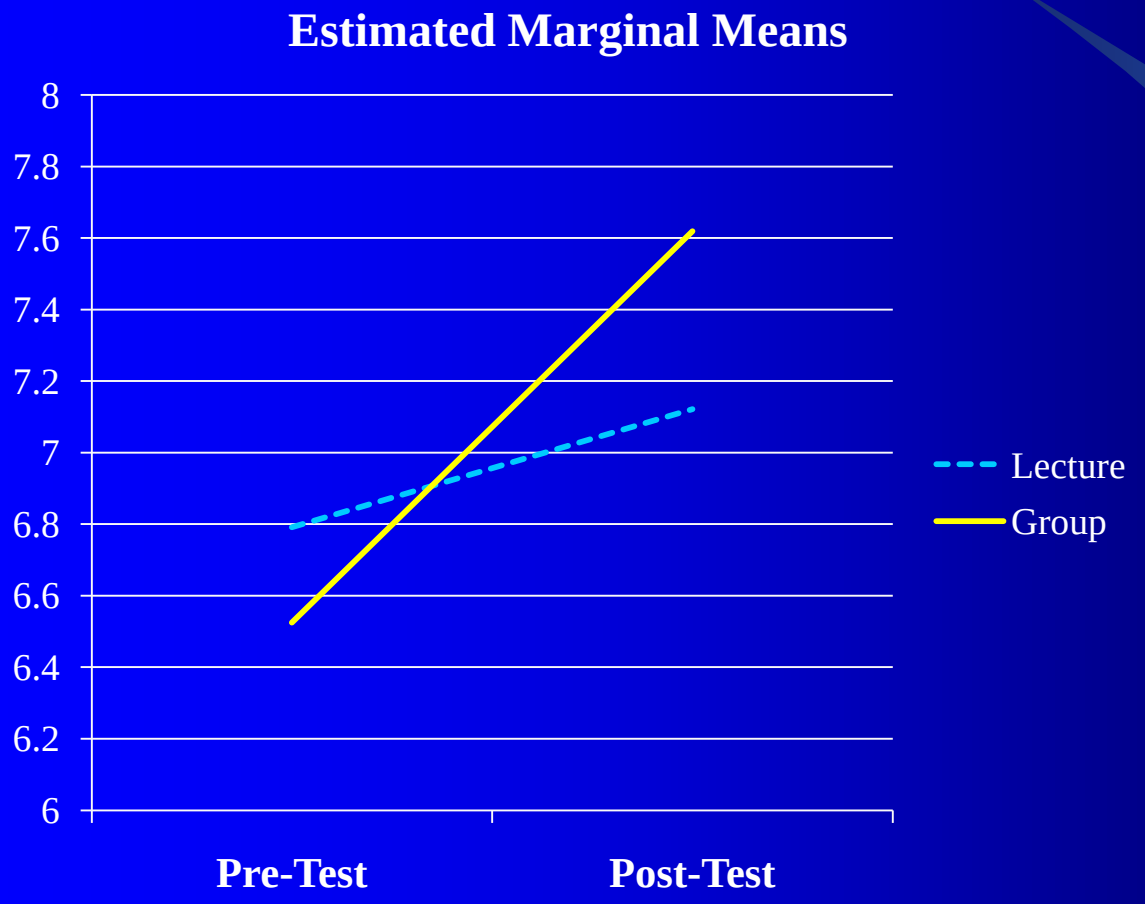
Repeated Measures ANOVA
N=234
Lecture=115
Group=119
Significant difference ($p<0.05$) in favor of Group treatment.
Wilks Lambda
Time: $\lambda=0.562$
Time*Treatment: $\lambda=0.876$

Maximum score 20

Accuracy Analysis

- Pre- and Post-tests evaluated for accuracy of answers
- Scale of 0-10
  - two problems had multiple parts
- Significant effect pre- to post- for all treatments taken together
- Significant difference in favor of group treatment

Accuracy Analysis



Repeated Measures ANOVA
Significant difference ($p<0.05$) in favor of Group treatment.
Wilks' Lambda
Time: $\lambda=0.872$
Time*Treatment: $\lambda=0.960$

Maximum score 10

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, communications abilities, and accuracy

Limitations

- Rater training on rubric
  - Only moderate --- 8 raters
  - Revised; now piloting new rubric
- Accuracy gain on post-test low
  - Less than 1 in mean (out of 10)
  - Less than 1 SD from pre-test
  - Objective questions added to pre/post-test; now piloting
- Unit of significance
  - Student versus class
  - Correlation of variance because of a common experience
  - Theory versus practice --- suppression of differences

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