What we learned from the Good Questions Project

Maria Terrell

Cornell University

Project was partially supported by a grant from the National Science Foundation grant DUE-0231154 and from a grant from the Cornell Faculty Innovations in Teaching Program.

The Good Questions Project

Goals:

- Adapt Eric Mazur's ConcepTests and Peer Instruction in physics to teaching calculus
- Write and test peer discussion questions for a large multisection first semester calculus course
- Assess gains(or loss) in performance on Cornell's traditional calculus exams

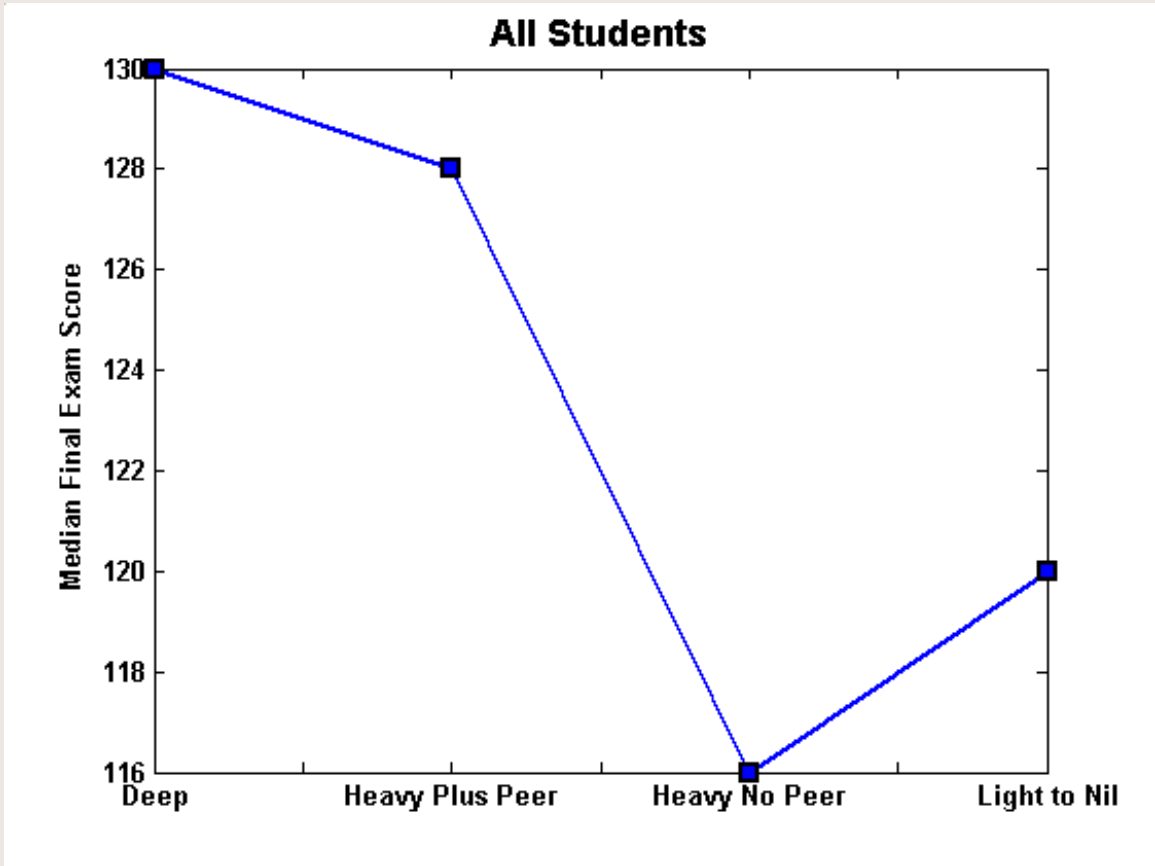
The Trial- Fall 2003

- Data collected
  - Instructors use/nonuse of questions
  - Types of questions used (Q,P,D)
  - Instructors use/nonuse of peer discussion
  - Student performance on common exams (conceptual and traditional)
  - Student SAT V/M and demographic data
  - Student Surveys
- What the data suggest
  - Exam results
  - Student interviews-Videos

Four groups

- *Deep* -- many Deep and Probing questions with peer discussion, GQ used 1-4 days per week;
- *Heavy Plus Peer*-- GQ used 3-4 days per week, regular use of peer discussion;
- *Heavy Low Peer*-- GQ used 3-4 times per week but minimal/no use of peer discussion;
- *Light to Nil Low Peer*- GQ used rarely or not at all with no use of peer discussion.

Final Exam score medians out of 150 points



T Tests for difference of means

- Three preliminary exams 100 point each.
- Conceptual sub scores
- Final Exam Cumulative 150 points.
- No Peer discussion/ Peer discussion

T tests difference of means M/W

Women

Variable	No Peer Means	N	Peer Means	N	Null: Means Equal? ($\alpha = 0.05$)	Level of Significance
Prelim1	82 (B)	76	86 (B+)	57	Reject	0.015822
Prelim1 Con.	19	76	21	57	Accept	0.056766
Prelim2	76 (B-)	86	79 (B)	56	Reject	0.025198
Prelim2 Con.	18	86	20	56	Reject	0.028832
Prelim3	73 (B-)	85	76 (B-)	57	Accept	0.10499
Prelim3 Con.	33	83	34	57	Accept	0.23062
Final Exam	115 (B-)	86	125 (B)	56	Reject	0.0023054

Men

Variable	No Peer Means	N	Peer Means	N	Null: Means Equal? ($\alpha = 0.05$)	Level of Significance
Prelim1	83 (B)	60	87 (B+)	40	Reject	0.041932
Prelim1 Con.	21	59	22	40	Accept	0.19529
Prelim2	76 (B-)	66	80 (B)	40	Reject	0.032915
Prelim2 Con.	18	66	21	40	Reject	0.005643
Prelim3	71 (C+)	66	78 (B-)	39	Reject	0.0058032
Prelim3 Con.	31	65	35	39	Reject	0.0092971
Final Exam	118 (B-)	66	126 (B)	40	Reject	0.015522

T test difference of means URM

Under Represented Minorities

Variable	No Peer Means	N	Peer Means	N	Null: Means Equal? ($\alpha = 0.05$)	Level of Significance
Prelim1	78 (B-)	18	81 (B)	22	Accept	0.21859
Prelim1 Con.	17	18	19	22	Accept	0.28009
Prelim2	69 (C)	24	72 (C+)	22	Accept	0.29334
Prelim2 Con.	17	24	17	22	Accept	0.4776
Prelim3	67 (C)	24	71 (C+)	21	Accept	0.19238
Prelim3 Con.	30	24	31	21	Accept	0.32179
Final Exam	106 (C)	24	117 (B-)	21	Reject	0.037757

Benefits of voting

Benefit of Talking

The whole process

What the data suggest

- Good Questions appear to have a positive effect on student learning when used *with* peer discussion, but not if used *without* peer discussion.
- Questions that promote deeper discussions of key concepts appear to enhance learning.

Some surprising responses

Some sample questions and student response data

T/F:

- You were once exactly 3 feet tall.
- First vote T=.80, F=.20, after discussion T=.90, F=.10
- You were once exactly π feet tall.
- First vote T=.40, F=.60 after peer discussion T=.85 F=.15

Precalculus
Questions about numbers

- T/ F: .999…=1
- First vote: T=.5, F=.5, revote: T=.45, F=.55

- The distance between *a* and *b* on the number line is less than 1/10, 1/100, 1/1000,…1/10^N,… for any counting number N. Then we know
  - A) *a*=*b*. (First vote 10%, revote 8%)
  - B) *a* and *b* are very close but they are not necessarily equal. (First vote 85%, revote 90%)
  - C) *a* and *b* are not equal. (First vote 5%, revote 2%)

Adding two numbers

a=.393939… and b=.676677666777… then $a+b$

a) is not defined because the sum of a rational and irrational number is not defined. (41%)
b) is not a number because not all infinite decimals are numbers. (8%)
c) is defined using successively better approximations. (23%)
d) is not a number because the pattern may not be predictable indefinitely. (38%)

Ratio of two numbers

A number close to 0 is divided by a number close to, but not equal to 0. The result

a) is a number close to 0. (vote 19%, revote 0%)
b) is a number close to 1. (vote 22%, revote 0%)
c) is a very big number. (vote 31%, revote 2%)
d) could be any number. (vote 20%, revote 98%)
e) is not a number. (vote 8%, revote 0%)

Questions for further discussion

- What concepts from arithmetic of real numbers are prerequisite for the study of calculus?
- Is the Archimedean property necessary or unnecessary for understanding limits?

Is it time to take a closer look at the real numbers?