Summary

110 only
Data File: 195 paired PRE/POST,
overall 304 entries,, 109 POST only (PRE only were removed)

Semester	Paired Responses	Total Responses
Fall 2009	52	80
Spring 2010	19	31
Fall 2010	52	74
Spring 2011	72	119
Total	**195**	**304**

Process:
1. Administered by SurveyMonkey (2 SPSS files per semester: PRE & POST)
2. Removed personally identifiable info
3. Joined all the PRE, Joined all the POST files separately
4. Created individual "anonID" to be able to match PRE and POST cases, created teacher and course info column etc.
5. Merged files using anonID as a matching variable
6. Extracted all the cases that listed"Math 110" in POST (survey also administered in other classes and we were only interested in matched data)

Statistical Process:
Computed Reliabilities (Cronbach): tablecompositevariables.xls
the Colorado groupings had appropriate reliabilities for our students, as well.
Then computed
significance levels & effect sizes for changes in beliefs/attitudes, and
cross-correlations between beliefs/attitudes and
(a) classroom experiences and
(b) learning gains.

Cross-correlation Beliefs/Attitudes vs. (a) Classroom Experiences and (b) Learning Gains

We computed cross-correlation between Beliefs/Attitudes scales (POST) on the one hand and (a) Experiences and (b) Learning Gains on the other.

We find many, many, many significant correlations: e.g.

The following Belief/Attitude scales correlate with ALL Experience and Gains scales: *Interest, Enjoyment, Group Work, Exchange of Ideas, Collaborative, Self-regulation*

The gender differences reported for Beliefs/Attitudes also shine through here.

Beliefs and Attitudes (overall)

The survey instrument and the analysis scales were created by Ethnography & Evaluation Research (E&ER), an independent research unit at the University of Colorado Boulder, for a large-scale study of IBL and non-IBL courses for mathematics majors at four major universities.

We administered the PRE/POST survey in all our sections of MATH 110 over four semesters, receiving 304 student responses, which we could match in 195 cases.

All the PRE/POST comparisons of survey results show changes in the directions we were hoping for (even if they are not all significant).

Significance Levels and Effect Sizes for changes in Beliefs & Attitudes *(Effect Size)*

At <.001 level:	*interest (0.37), enjoyment (0.34), interaction (0.30)*
At < .01 level:	*group work (0.24), instructor-centered (-0.18)*
At < .05 level:	*extrinsic goals (-0.19), reasoning (0.18)*

We found significant positive changes in student motivation, enjoyment, and beliefs about learning as follows.

Interest: Students report that they are more likely
- to read magazine or newspaper articles related to math,
- to bring up mathematical ideas in a non-mathematical conversation,
- to participate in a club or organization related to math.

Enjoyment: Student report increased enjoyment in
- Working on a challenging mathematical problem,
- Discovering a new mathematical idea,
- Seeing mathematics in everyday life,
- Perceiving beauty in mathematical ideas,
- Using rigorous reasoning in a math problem, and
- Thinking about abstract concepts.

Interaction: Students believe more strong in learning mathematics best when they
- can compare my math knowledge with other students.,
- explain ideas to other students,
- get frequent feedback on their mathematical thinking.

The changes at the lower significance level actually mask much more significant changes that fall along gender lines. For the scales of *group work (women: 0.26), instructor-centered (women: -0.22), extrinsic goals (women: -0.28), the changes are* highly significant for women ($p<.01$), but not significant for men at all. Conversely for *reasoning*: here the changes are highly significant for men (men: 0.42), but not significant for women.

Overall, the order of magnitude in our effect sizes is comparable to those seen in the study by E&ER.

((We can make similar list for *group work etc. based on the questions shown below.))*

Detailed questions to unravel what *interest* etc means:

Interest: HOW LIKELY is it that you will ...

Read magazine or newspaper articles related to math?
Bring up mathematical ideas in a non-mathematical conversation?
Participate in a club or organization related to math?

Enjoyment: HOW MUCH do you ENJOY ...

Working on a challenging mathematical problem?
Discovering a new mathematical idea?
Seeing mathematics in everyday life?
Perceiving beauty in mathematical ideas?
Using rigorous reasoning in a math problem?
Thinking about abstract concepts?

Interaction: I learn mathematics BEST when ...

I can compare my math knowledge with other students.
I explain ideas to other students.
I get frequent feedback on my mathematical thinking.

Group-work: I learn mathematics BEST when ...

The class critiques other students' solutions.
I work on problems in a small group.
Groups present their solutions in class.

Instructor-centered: I learn mathematics BEST when ...

The instructor lectures.
The instructor explains the solutions to problems.
The homework assignments are similar to the examples considered in class.
I study my class notes.

Extrinsic Goals: HOW important is each GOAL to you?

Learning specific procedures for solving math problems
Getting a good grade in college mathematics courses
Memorizing the sets of facts important for doing mathematics
Meeting the requirements for your degree

Reasoning: In order to solve a challenging math problem, I NEED...

To carefully analyze different possible solutions.
To try multiple approaches to constructing a solution.
To use rigorous reasoning.
To have freedom to do the problem in my own way.
To work hard

Beliefs/Attitudes by Gender:

For the scales with the largest effects, the changes are highly significant for both genders, with slightly higher effect sizes for the men:

At <.01 level: *interest (m: 0.41, w: 0.37), enjoyment (m:0.45, w: 0.30), interaction (m: 0.39, w: 0.29)*

So the strongest positive effects are real for all students regardless of gender.

Interesting gender differences:

Highly significant changes for women (<.01), but not significant for men:
group work, instructor-centered, extrinsic goals

Highly significant changes for men (<.001), not significant for women:
reasoning

Summary Paragraphs

Significance Levels and Effect Sizes for changes in Beliefs & Attitudes *(Effect Size)*

At <.001 level:	*interest (0.37), enjoyment (0.34), interaction (0.30)*
At < .01 level:	*group work (0.24), instructor-centered (-0.18)*
At < .05 level:	*extrinsic goals (-0.19), reasoning (0.18)*

Interest, Enjoyment, and Interaction are highly significant for all students (independent of gender), with reasonable effect sizes. The changes are especially significant given that the questions asked for fairly substantial evidence of increased *Interest* and *Enjoyment*.

Interest: HOW LIKELY is it that you will ...
Read magazine or newspaper articles related to math?
Bring up mathematical ideas in a non-mathematical conversation?
Participate in a club or organization related to math?

Enjoyment: HOW MUCH do you ENJOY ...
Working on a challenging mathematical problem?
Discovering a new mathematical idea?
Seeing mathematics in everyday life?
Perceiving beauty in mathematical ideas?
Using rigorous reasoning in a math problem?
Thinking about abstract concepts?

The changes at the lower significance level actually mask much more significant changes that fall along gender lines. For the scales of *group work, instructor-centered, extrinsic goals, the changes are* highly significant for women (p<.01), but not significant for men at all. Conversely for *reasoning*: here the changes are highly significant for men (p<.001), but not significant for women.

Comparison with Colorado Report

The survey instrument and the analysis scales were created by Ethnography & Evaluation Research (E&ER), an independent research unit at the University of Colorado Boulder, for a large-scale study of IBL and non-IBL courses for mathematics majors at four major universities (web link to IBL page at E&ER).

In their 2011 "Evaluation of the IBL Mathematics Project: Student and Instructor Outcomes of Inquiry-Based Learning in College Mathematics" they report average changes in Beliefs, Motivation and Strategies for students in IBL math-track, non-IBL math-track, and IBL pre-service teachers. The largest effect sizes are seen in IBL pre-service teachers, with a strong decline in *math future* motivation (-0.41) and *self-regulatory* strategies (-0.36). For IBL math-track students, the strongest effects are increases in *communicating* goals (+0.25), beliefs in *group work* (+0.25) and *collaborative* strategies (+0.24).

Strikingly, for non-IBL math track students, the largest effects are seen with a decline in confidence in their *math ability* (-0.33) and a decrease in *math future* as a motivation (-0.24).

They write:

> *Overall, the results [from the survey] suggest that IBL math courses tended to promote more sophisticated and expert-like views of mathematics and more interactive approaches to learning. In contrast, traditional mathematics courses appeared to weaken students' confidence and enjoyment, and did not help them to develop expert-like views or skillful practices for studying college mathematics.*