What matters? Mathematics classes for elementary teachers

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The ME.ET Project

The Mathematical Education of Elementary Teachers

- What is taught and learned in undergraduate mathematics classes that elementary teachers take for certification? Can we explain "what works"?
- How do these classes relate to current policy and knowledge about mathematics teaching and learning?

Elements of the Study

K-8 Students	ACHIEVEMENT IN MATHEMATICS
Future Teachers	Prior knowledge, math coursework, attitudes, year in program
Instructors	Preparation, experience, attitudes, rank, methods
Institutional Contexts	Course requirements, textbooks, assessments, instructor selection
Policy & Research Contexts	Standards, tests, policy documents, and research

Elements of the Study

Future teachers mathematical knowledge is a leverage point for increasing K-8 student achievement

Future Teachers	Prior knowledge, math coursework, attitudes, year in program
Instructors	Preparation, experience, attitudes, rank, methods
Institutional Contexts	Course requirements, textbooks, assessments, instructor selection
Policy Contexts	Standards, tests, policy documents

Data

- Survey of mathematics departments
- Survey of instructors
- Pre-Post tests of future teachers*
- Analysis of textbooks
- Observations in classes

*I will call them "STUDENTS" in this talk.

Numbers

- Pre-Post tests: 2576 (LMT Items)
  - Matched pre-post tests: 836
  - From 54 classes of 43 instructors
- Instructors: 80
- Math Departments: 57
- Locations: 4 states
- Textbooks: 13
- Observation sections: 8

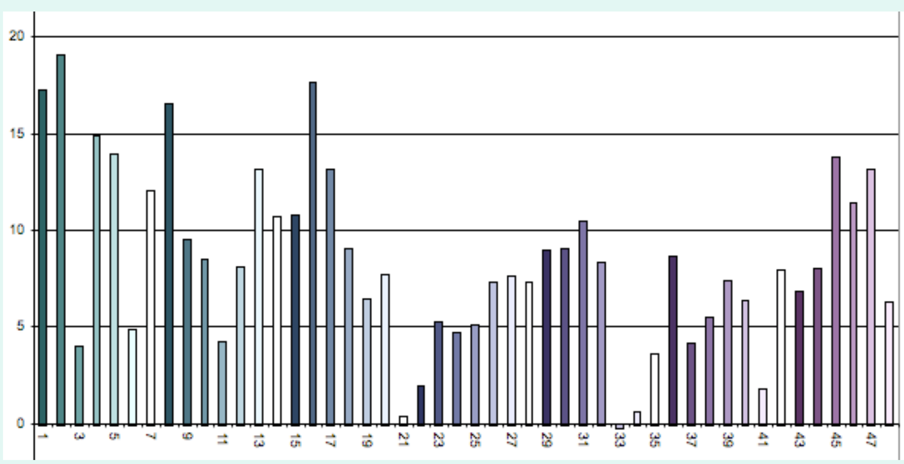
LMT Items

- Developed at Michigan
- Used IRT parameters
- Standardized results
  - Set pretest mean to 50
  - Standard deviation to 10

Focus of this talk

Can we explain differences in student achievement across instructors based on characteristics of students, instructors, and classroom context?

Differences across instructors



Characteristics of students

- Pretest Score
- Predictors of gain
  - SAT/ACT
  - Attitude toward math
  - Socio-economic Status
  - College mathematics classes
  - Year in college

Characteristics of Instructors

- Instructional methods
- Attitude toward teaching the course
- Goals
- Knowledge of math ed policy and standards documents
- Experience
- Rank
- Control
- Time on task

Characteristics of the Context

- Instructional materials
  - What textbook is used (if any)
  - How textbook is used (how much, for what purposes)
- Class size
- School quality
  - Average SAT/ACT overall
  - Average SAT/ACT reported by the class

Characteristics of Students

Variables	Coding and Range	Mean	SD
Pretest Score	17 – 82	50.68	10.20
Prior Knowledge (CACT)	12 – 36	23.19	4.41
I like Math	0 = Strongly disagree, disagree, undecided 1= Strongly agree or agree	0.39	0.49
College Level	1 = Freshman 2 = Sophomore 3 = Junior 4 = Senior or higher	2.22	0.90
College Math Coursework	0 = none 1 = 1 2 = 2 3 = 3 4 = 4 or more	2.47	1.12
SES (Mother Education)	0 = Mother has no higher education 1 = Mother has higher education	0.46	0.50

Characteristics of Students

	1	2	3	4	5	6	7	Variable Explanation
1	1.00	*0.48	*0.48	*0.08	-0.01	-0.01	*0.13	Pretest Score
2		1.00	*0.38	*0.11	-0.03	-0.01	*0.09	Post test Score
3			1.00	*0.28	-0.04	-0.01	*0.12	Prior Knowledge (C_ACT)
4				1.00	0.01	*0.14	-0.01	Attitude toward Math
5					1.00	*0.51	*-0.08	College Level
6						1.00	*-0.08	College Math Coursework
7							1.00	SES (Mother Education)

*Correlation significant at the .05 level

Characteristics of Instructors

Variables	Coding and Range	Mean	SD
Primary Textbook from choice of 13	1 = a primary textbook on our list 0 = not a textbook on our list	0.65	
Primary Textbook from choice of 3	1 = Beckmann, Billstein,or Parker 0 = Not Beckmann, Billstein, or Parker	0.38	
Class Size	4 – 53	26.68	9.61
CACT	12 – 36	23.03	3.63
Years College Teaching Experience	0 – 41	15.73	10.79
Interest in teaching this course	0=no interest at all 1=limited interest 2=some interest 3=a great deal of interest	2.71	0.63
Interest in teaching this course again	0=no interest at all 1=limited interest 2=some interest 3=a great deal of interest	2.75	0.59
Control Score	9 – 28	23.03	5.24
Teaching Methods	6 – 34	19.85	6.45

Measuring Instructional Methods

- **In your mathematics course, how often do your students engage in each of the following activities?** Please check the box that best describes what happens in your course. The scale of responses ranges from 0, “Never or almost never”, to 3, “Every lesson”

Measuring Instructional Methods

- Explain the reasoning behind an idea
- Work on problems for which there is no immediate method of solution
- Listen to you explain terms, definitions, or mathematical ideas (Reversed)
- Listen to you explain computational procedures or methods (Reversed)
- Analyze similarities and differences among several representations, solutions, or methods
- Work on mathematical communication and/or representation
- Make conjectures and explore possible methods to solve a mathematical problem
- Discuss different ways that they solve particular problems
- Write about how to solve a problem in assignments or tests
- Do problems that have more than one correct solution

- Range of Total Score: -6 to 24
- In models, used the mean as the center point for analysis.

Modeling

- Growth model using Hierarchical Linear Modeling techniques
- Needed because students variable are not independent -- they are grouped by section instructor, school
- HLM is simply regression repeated over and over
- Bayesian techniques -- multiple iterations until the model settles down

Models

- THREE LEVELS
  - Level 1: Growth “waves” from pre- to post: Uses ALL the data
  - Level 2: Student
  - Level 3: Instructor
- ESTIMATING coefficients to fit the data to the model
- The Bayesian model pulls estimates toward the center, mediating the extremity of outliers

Models

Level 1- Growth:

Y = P0 + P1*(TIME) + E (TIME is 0 or 1)

Level 2 - Student:

P0 = B00 + R0

P1 = B10 + R1

Level 3 - Instructor:

B00 = G000 + U00

B10 = G100 + U10 (E, R, and U are random error)

Unconditional Model

- This PARTITIONS the variance into levels
  - Mean Pretest: 50.77
  - Average gain: 7.36 (where SD = 10)
  - Student level variance: 4.04
  - Instructor level variance: 5.75

    (Variance is a pure number with no units)

Hypothesis 1

- Student's prior knowledge, measured by CACT will predict gain score.

Level-1 Model (Growth level)
Y = P0 + P1*(TIME) + E
Level-2 Model (Student level)
P0 = B00 + R0
P1 = B10 + B11*(C_ACT) + R1
Level-3 Model (Instructor level)
B00 = G000 + U00
B10 = G100 + U10
B11 = G110

Hypothesis 1

Student's prior knowledge, measured by CACT will predict gain score.

Fixed effects:

- 52.07 Mean Pretest score
- 7.39 Mean gain for average CACT
- 0.46 Slope for CACT score

Best model (so far)

- Level 1: Growth model
- Level 2: Fixed CACT
- Level 3: Primary Textbook, Methods

Level 1 Model
  Y = P0 + P1*(TIME) + E
Level-2 Model
  P0 = B00 + R0
  P1 = B10 + B11*(CACT) + R1
Level-3 Model
  B00 = G000 + U00
  B10 = G100 + G101(TEXT_PRI) + G102(METHODS) + U10
  B11 = G110

Best model (so far)

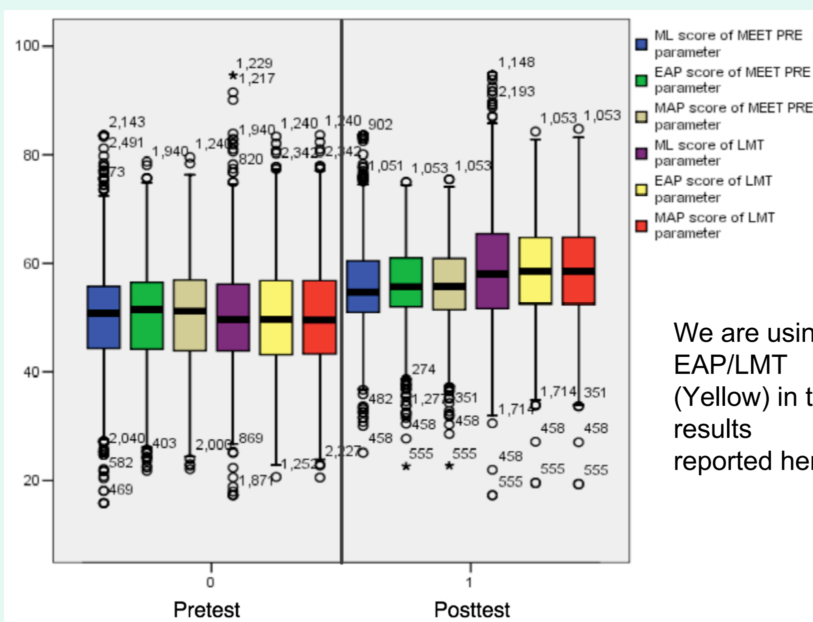
- Level 1: Growth model
- Level 2: Fixed CACT
- Level 3: Primary Textbook, Methods

Mean Pretest: 51.83
Average Gain, no primary textbook, average methods: 4.36
Average Gain, Add primary textbook 4.40
Average Gain, Change in methods: 2.59

» So, an instructor who uses one of the books and is one point above average in methods would have a predicted posttest score of:
» 51.83 + 4.36 + 4.40 + 2.59 = 62.18

Issues in Analysis

- Item Parameters: Calculate our own or use LMT?
- Using gain or posttest as outcome?
- Assumptions of regression model
  - With measurement error
  - Without measurement error
- Estimation method
  - Maximum likelihood
  - Maximum a posteriori (MAP)
  - Expected a posteriori (EAP)



We are using EAP/LMT (Yellow) in the results reported here

Lessons to take away

- ABOUT PROCESS
  - Measuring knowledge is complex
  - Getting permissions (IRB) is tricky
  - Developing models requires judgment not merely cranking out numbers

- ABOUT SUBSTANCE
  - Textbook matters
  - Students' prior knowledge matters
  - Teaching methods matter

What have we learned?

- In other parts of the project
  - Methods for comparing textbook content at a detailed level
  - Analyzing lessons on multiplication of fraction
  - Analyzing lessons with attention to proof and justification
  - Diversity of instruction: many approaches to the same content
  - Methods of analyzing this diversity

THANK YOU!

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- Suggestions, questions, comments always welcome!