Longitudinal Changes in K-3 Teachers' Mathematical Content Knowledge for Teaching, Attitudes, and Beliefs

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NebraskaMATH

- Targeted Math Science Partnership grant ($9.2 million, 2009-2014) from the National Science Foundation
- Built on previous Math Science Partnership Institute for middle level mathematics teachers (Math in the Middle, 2004-2011, $5 million)

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- Goal was to create statewide K-16 partnership that would work to improve mathematics achievement in Nebraska
- Included programs for K-3 and secondary teachers

Statement of the Problem

- Early math skills have positive effects on later math (and reading) learning and achievement (e.g., Duncan et al., 2007; Clements & Sarama, 2009)

- Elementary math specialist (EMS) programs offer a hopeful approach

Philosophy of Teacher Change

- Change is slow & difficult (Guskey, 2002)
- Beliefs & practice change in related but non-linear manners (Fullan, 2001)
- Change is provoked through inquiry and ongoing learning/reflection are critical (Cochran-Smith & Lytle, 2009)
- Teachers learn *in* and *from* their practice (Lampert, 2010)

Program Description

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- **Six-course, 13-month EMS program for K-3 teachers**
  - 3 math courses, 3 pedagogy courses, & 1 optional leadership course
- **Includes three aspects of high-quality in-service PD** (Wilson & Berne, 1999)
  - Opportunities to talk about *subject matter*
  - Opportunities to talk about *students and learning*
  - Opportunities to talk about *teaching*
- **Providing time for consolidation, growth, and change**

Primarily Math Participants

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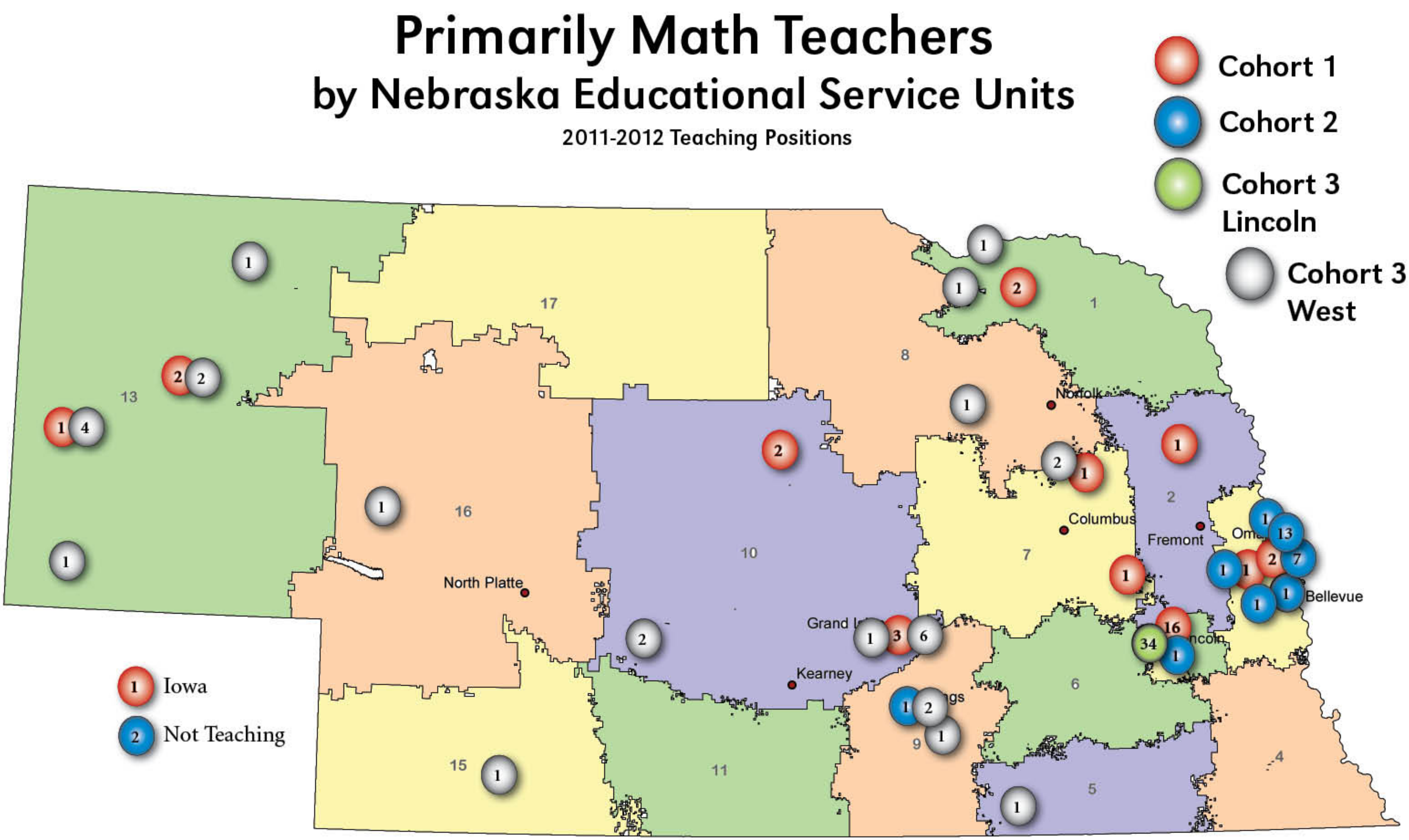

Sequence of Courses

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	Course Title
Summer Institute I	Number & Operations, Part I
	Number & Operations, Part II
Fall Semester	Teaching Math K-3: Planning Lessons for Diverse Learners
Spring Semester	Helping Young Children Become Mathematical Thinkers
Summer Institute II	Geometry and Algebraic Thinking
	Communities of Practice and Mathematics

Structure and Content of Courses

Summer Institutes:

Mathematics Coursework Structure

•***Active learning*** (small group work, participant presentations, whole group discussion)

•***Daily mathematics problem sets*** with problems ranging from easy to very complicated "habits of mind" problems which had multiple solution paths and often multiple solutions.

•The ***end-of-course problem set*** included more problems that require teachers to return to earlier course problems to improve on their solutions, and reflect on their learning.

Structure and Content of Courses

Sample Math Class Problem

Suppose Laura is a student in your classroom and declares that she has made the following discovery:

As the perimeter of a rectangle increases, so does the area.

Do you agree? Either verify or disprove Laura's assertion and describe how you might respond to Laura.

Structure and Content of Courses

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Academic Year:

Pedagogy/Child Development Coursework

- Major Assignments include:
  - Cycles of lesson/unit planning
  - Reflect on videotaped lessons
  - 2 cycles of Family projects
  - Child Study
  - Talk Moves
  - Leadership Plan
- Other assignments include scholarly readings & professional writings; online discussion board posting

Overall Research Questions

- In what ways do the mathematical attitudes of participants and the teachers they influence change over time?

- What mathematical knowledge and pedagogical habits of mind do K-3 teachers possess as a result of their participation in Primarily Math?

Research Question for this Summit

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How did teachers' knowledge for teaching, attitudes, and beliefs change after participating Primarily Math?

Review of the Literature

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- Teachers can teach young children effectively if they have:
  - Deep mathematical knowledge for teaching
  - Positive attitudes toward learning mathematics
  - Student-centered beliefs about teaching mathematics

Measurable Aspects of Effective Teaching

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- **Mathematical Knowledge for Teaching**
  - Analyze and understand student thinking
  - Empirically linked to mathematics instruction and predicts student gain scores (Hill, 2013)
- **Attitudes Toward Learning Mathematics**
  - Mathematics anxiety is "contagious" (Beilock et al, 2010)
  - Related to mathematics instruction
- **Beliefs about Mathematics Teaching**
  - Relate to teaching practices
  - Intense field experience & reflection change beliefs

Analytic Strategy

- Two sets of analyses:
  - Within-cohort change
  - Between-group change (PM vs matched controls)

Method

- **Participants**
  - 218 K-3 teachers: 126 Primarily Math teachers (3 cohorts), 92 non-participating teachers
  - Matching at building-level characteristics
- **Measurements**
  - Mathematical Content Knowledge for Teaching Survey (MKT; Hill et al., 2004)
  - Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976)
  - Mathematics Beliefs Scales (Fennema, Carpenter, & Loef, 1990; Caprano, 2001)

Mathematical Content Knowledge for Teaching

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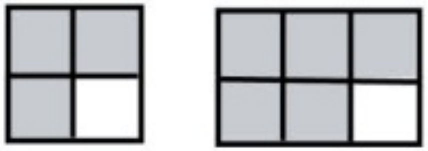
- Measures K-6 teachers' knowledge of mathematics as it relates to teaching elementary math
  - Concepts
  - Representations
  - Understanding Student Thinking/Errors
  - Choosing Examples
- Scores are reported as IRT scores, based on a large national sample of K-6 teachers, where IRT = 0 is interpreted as the national average
- Three subscales:
  1. Numbers & Operations
  2. Patterns, Functions, & Algebra
  3. Geometry

Hill, H.C., Schilling, S.G., & Ball, D.L. (2004) Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal, 105*, 11-30.

MKT Sample Item

16. Takeem's teacher asks him to make a drawing to compare $\frac{3}{4}$ and $\frac{5}{6}$. He draws the following:



and claims that $\frac{3}{4}$ and $\frac{5}{6}$ are the same amount. What is the <u>most likely</u> explanation for Takeem's answer? (Mark ONE answer.)

a) Takeem is noticing that each figure leaves one square unshaded.

b) Takeem has not yet learned the procedure for finding common denominators.

c) Takeem is adding 2 to both the numerator and denominator of $\frac{3}{4}$, and he sees that that equals $\frac{5}{6}$.

d) All of the above are equally likely.

Attitudes towards Learning Mathematics

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- **Confidence**

  "I am sure that I could do advanced work in mathematics."

  "For some reason even though I study, math seems unusually hard for me."

- **Anxiety**

  "My mind goes blank and I am unable to think clearly when doing mathematics."

  "I usually have been at ease during math tests."

- **Effectance-Motivation**

  "When a question is left unanswered in math class, I continue to think about it afterwards."

  "The challenge of math problems does not appeal to me."

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitude Scale: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education, 7*(5), 324-326.

Beliefs about Teaching Math and Student Learning

- **Teacher-Centered Beliefs**

  "Students learn math best by attending to the teacher's explanations."

  "Time should be spent practicing computational procedures before children are expected to understand the procedures."

- **Student-Centered Beliefs**

  "Teachers should allow students to figure out their own ways to solve simple word problems."

  "Most students can figure out a way to solve many mathematics problems without any adult help."

Ren, L., & Smith, W. M. (2013). Using the Mathematics Belief Scales short form with K-3 teachers: Validating the factor structure. In M. Martinez, & A. Castro Superfine, (Eds.), Proceedings of the 35th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, pp. 857-860. Chicago, IL: University of Illinois at Chicago.

Timeline of Study

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	2009	2010	2011	2012	2013
Cohort 1 (n = 34):	**Pretest**	Posttest	Follow-up 1	Follow-up 2	Follow-up 3
Cohort 2 (n = 25):	Baseline	**Pretest**	Posttest	Follow-up 1	Follow-up 2
Cohort 3 (n = 67):	Baseline	Baseline	**Pretest**	Posttest	Follow-up 1
Comparison (n = 92):	Occasion 1	Occasion 2	Occasion 3	Occasion 4	Occasion 5

Results: Within-Cohort Change

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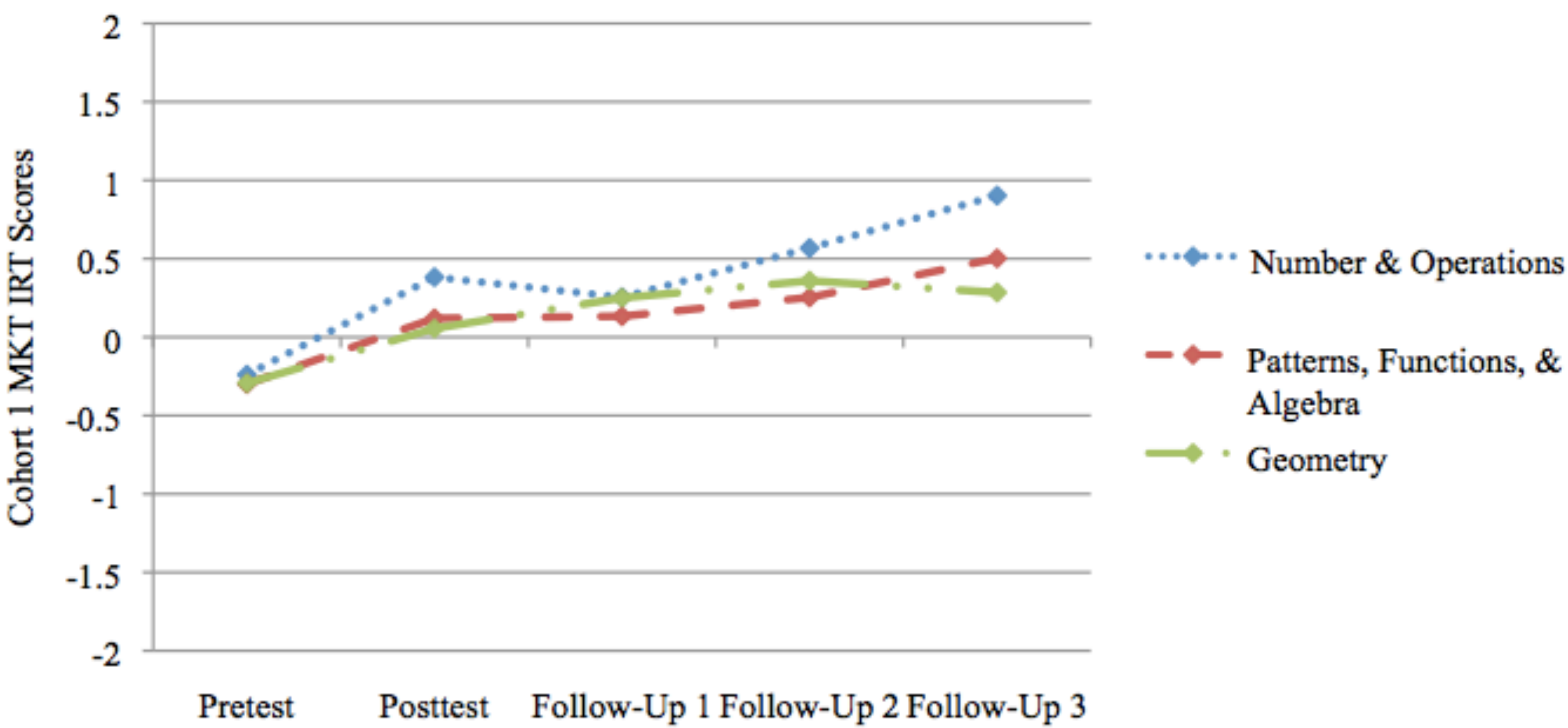
Mathematical Content Knowledge for Teaching:



Results: Within-Cohort Change

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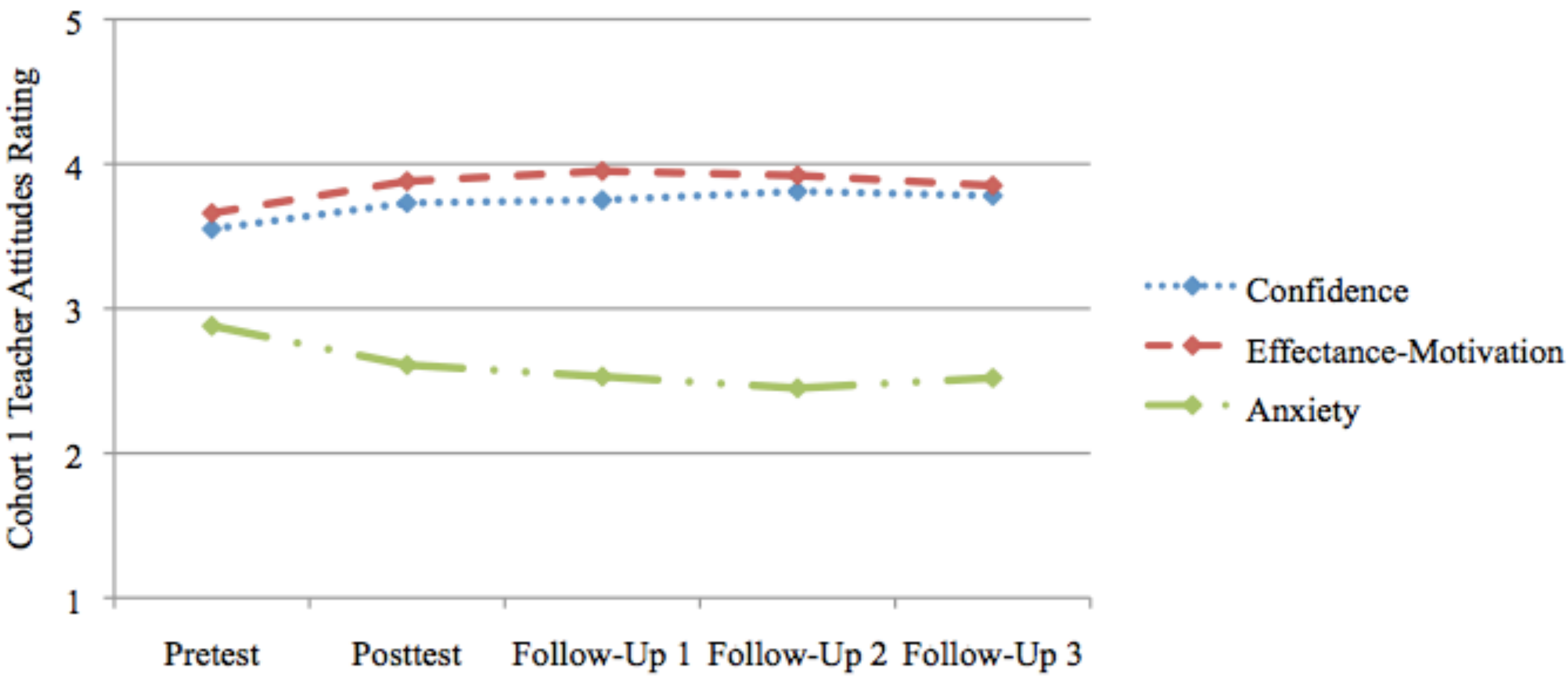
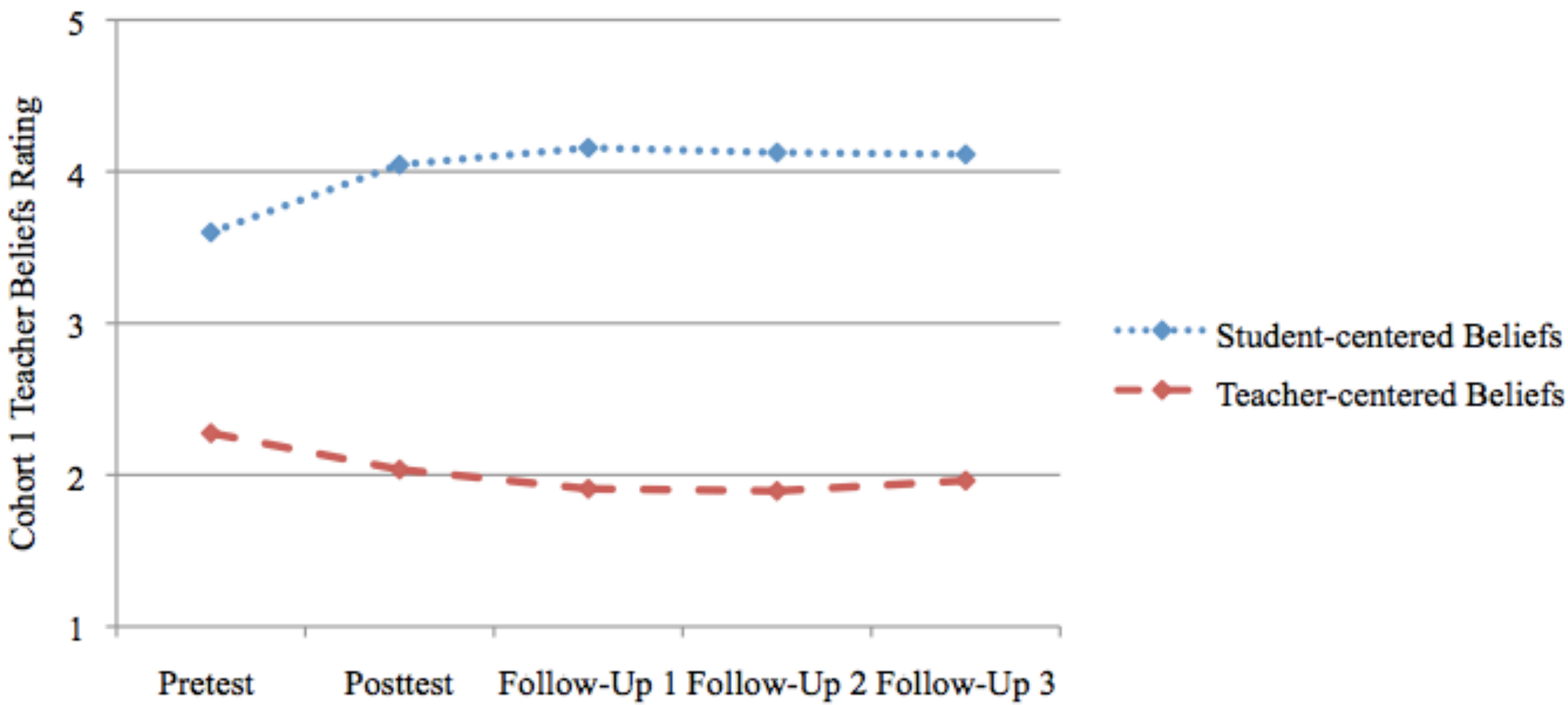
Attitudes toward Mathematics Learning:



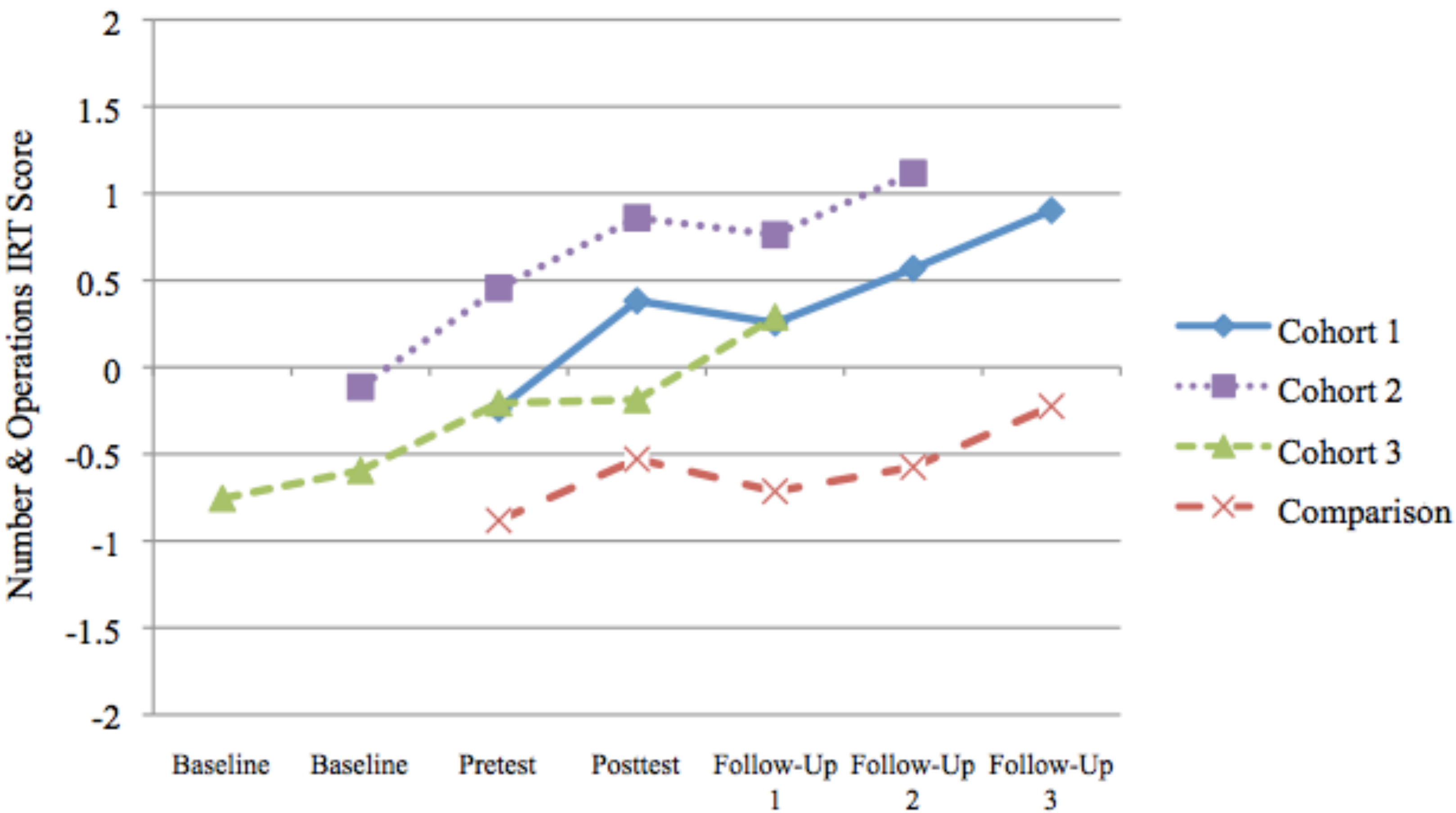
Results: Within-Cohort Change

Beliefs about Mathematics Teaching & Learning:



Results: Between-Group Change

Mathematical Content Knowledge for Teaching:



Results: Between-group Change

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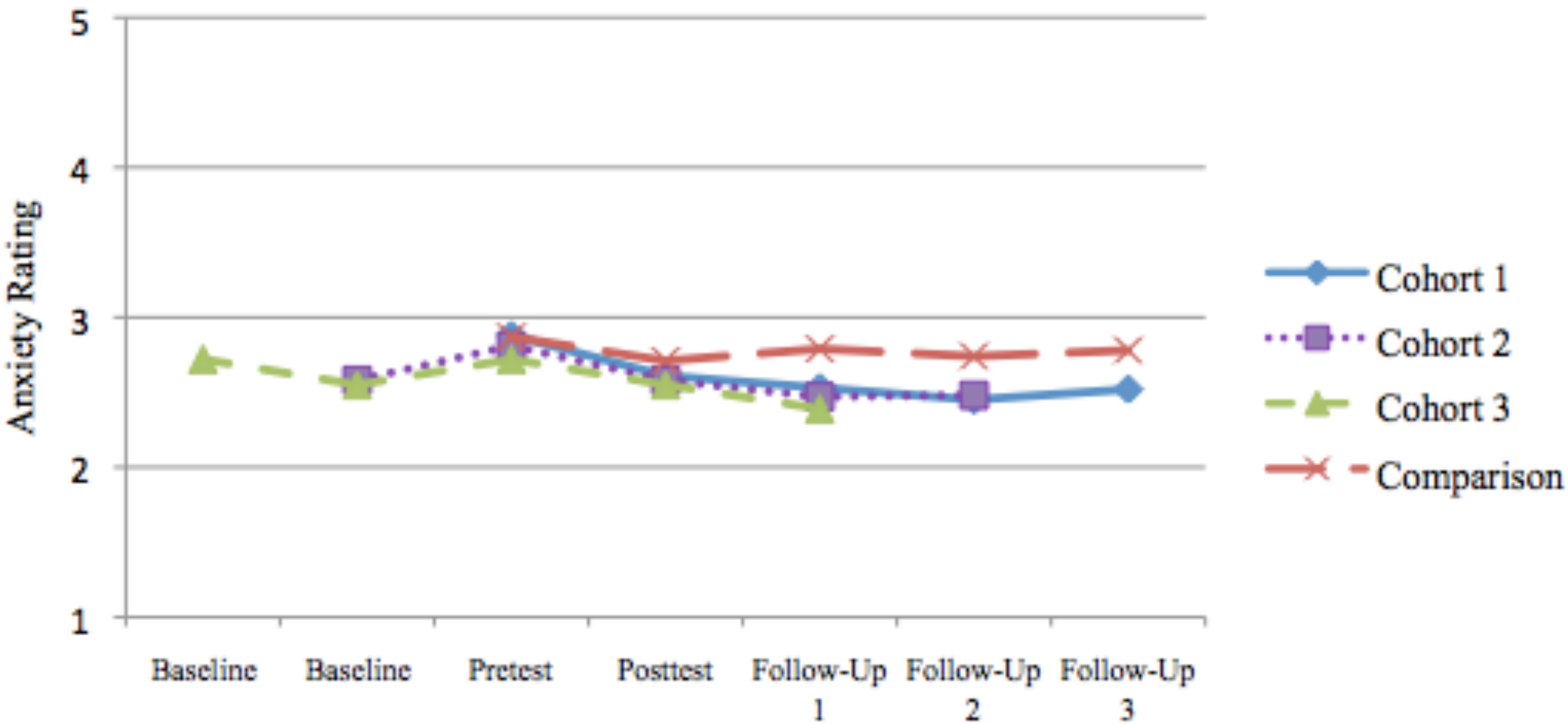
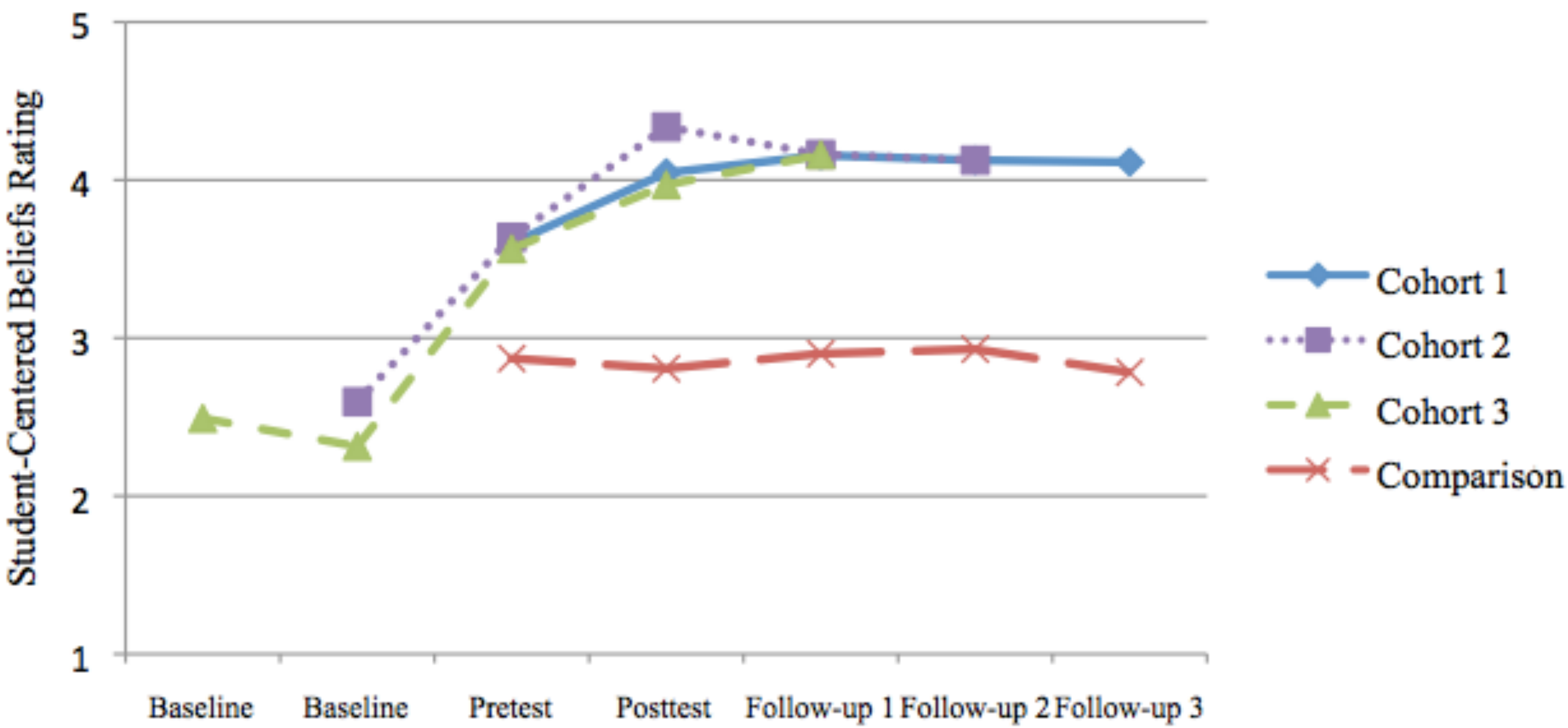
Attitudes toward Mathematics Learning:



Results: Between-group Change

Beliefs about Mathematics Teaching:



Interpretation of Model Results

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- **Why did teachers change?**
  - *Content* of the courses
  - *Sequence* of the courses
  - *Structure* of the courses
- **Holistic approach**
  - Primarily Math program is more than the sum of individual parts
  - Content, sequence, and structure of the coursework are collectively responsible for teacher changes
  - Professional Community

Limitations

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- Composition of comparison group
- Self-selection
- Attrition
- Matching at building level
- Quality of mathematical teaching

Future Directions

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- Understanding impact of Primarily Math on student achievement
  - Differential impact on students based on achievement
  - Access and inclusion of student-level data
  - Longitudinal trajectories

Implications

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1. Program success built on strong university-school district partnerships and long-term commitments by teachers, administrators, and university personnel.

2. Over 260 K-3 teachers in Nebraska have gained significantly in their mathematics knowledge for teaching

3. Over 260 K-3 teachers have reduced mathematics anxiety, heightened confidence to learn mathematics, and more child-centered teaching beliefs

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