CONDUCTING LONGITUDINAL RESEARCH: CHALLENGES, BENEFITS, AND RECOMMENDATIONS

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Children's Measurement Project
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OUR STUDY

- A Longitudinal Examination of Children's Developing Knowledge of Measurement: Mathematical and Scientific Concept and Strategy Growth from Pre-K through Grade 5Principle Investigators
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Purpose of our longitudinal study

- Validating and revising hypothetical learning trajectories for measurement of length, area and volume (Clements & Sarama, 2009)
- Engage students in teaching process over multiple school years to characterize shifts in strategy and reasoning from level to level
- Inform curriculum design, professional development, and assessment projects

Theoretical Framework

Hierarchical Interactionism (Clements & Sarama, 2007) includes accounts of student cognition that culminate in learning trajectories (LTs) to describe cognitive development.

Hypothetical learning trajectory (Simon, 1995; Clements & Sarama, 2004). At each level there is:

- A learning goal (mathematical domain and topic)
- A likely path for learning (through levels of thinking)
- A description of mental *Actions on Objects*
- Instruction that guides students along that path, given our understanding (model) of their actions on objects at that level.

Methodology (1)

- We worked with students, within existing school programs, mostly on a “pull out” basis for clinical interview/ tutoring. Our partner schools were a parochial and a laboratory school at a university.
- A longitudinal **teaching experiment** (Steffe & Thompson, 2000)
  - Focused on 8 students from a parochial school in New York State, following the students from PreKindergarten into Grade 2, and
  - Another 16 students from a public school in Illinois, following the students from Grade 2 into Grade 5.
- We conducted a **design** experiment to validate three Learning trajectories (Cobb & Gravemeijer, 2008), including an ongoing process of amendment.

Methodology (2)

- An open-response assessment in Year 1.
- Cyclical set of approximately five teaching episodes per semester for seven consecutive semesters with each students (3.5 years).
  - 3 to 6 teaching episodes per year with each focus student;
  - 15 to 25 minute teaching episodes;
  - Two to five tasks per episode, these were video recorded.
- An open-response assessment given in Year 4.

Outcomes of the Research

- Improvements, revision and validation of LTs
  - Length
- Barrett, J. E., Sarama, J., Clements, D. H., Cullen, C., McCool, J., Witkowski, C., & Klanderman, D. (2012). Children's Abstraction of Iterative Units to Measure Linear Space: A Trajectory. *Mathematical Thinking and Learning, 14*(1), 28-54.

- Sarama, J., Clements, D. H., Barrett, J. E., Van Dine, D. W., & McDonel, J. S. (2011). Evaluation of a learning trajectory for length in the early years. *ZDM: the International Journal for Mathematics Education, 43*(5), 667-680.
  - Area, Volume and Units of Measure
- Barrett, J. E., Sarama, J., Clements, D. H., Cullen, C., Witkowski, C., Miller, A., & Klanderman, D. (2011). Childrens Strategies and Unit Iteration Concepts for Length, Area, and Volume (Grades 2–4). *ZDM: the International Journal for Mathematics Education, 43*(5), 637-650.
- Methodological products
- Daro, P., Mosher, F. A., & Corcoran, T. (2011) [with: J. Barrett, M. Battista, D. Clements, J. Confrey, V. Daro, A. Maloney, W. Nagakura, M. Petit, and J. Sarama]. *Learning Trajectories in Mathematics: A foundation for standards, curriculum, assessment, and instruction*. New York: Teachers College-Columbia University.

- Two chapters in a forthcoming book on learning trajectories in mathematics education (Confrey, Maloney, Nguyen, in press).
- Conference presentations and collaboration with other Mini-Center for Measurement researchers

Benefits of studying one student through multiple (4) years

- Case of Anselm: we followed students across different domains that would not be possible within a single year of their curriculum (Length, Area AND Volume content span grades 2-5).
  - This allowed us to look for coherence and abstraction about unit, and about iterations or structuring, but
  - We found wide variation in sophistication across these three sub-domains for some students (especially Anselm)
- we modified our analytical perspective and our organization of TE episodes after the second and third year, allowing us to capture important aspects of developing knowledge
- but this made it challenging to establish and follow trends.

Overview of challenges

- Student attrition
  - Initial need for a larger number of participant recruitment
    - 8 *background* students in addition to 8 *focus* students.
- Need to balance our research efforts to collect data (TE sessions) between background students and focus students.
- Manage and control the consistency of data collection across changes in the staffing of our project, with a variety of graduate research assistants (both sites).
- Coordinate multiple sources of data for analysis across the two research sites through four years.
- Maintain the analysis and reporting process through changes in staffing of graduate research assistants.

Specific challenges for participants

- Disadvantage of long-term participation by students
  - Recurring classroom interruptions for the teachers and students
  - Familiarity with the research process sometimes resulted in *reduced engagement* with the tasks and questions
  - Three of eight students dropped out at one research site during some parts of the fourth year.
  - Balance work with class and other students to “invite” focus students to continue their work.

Bridging from elementary into middle school

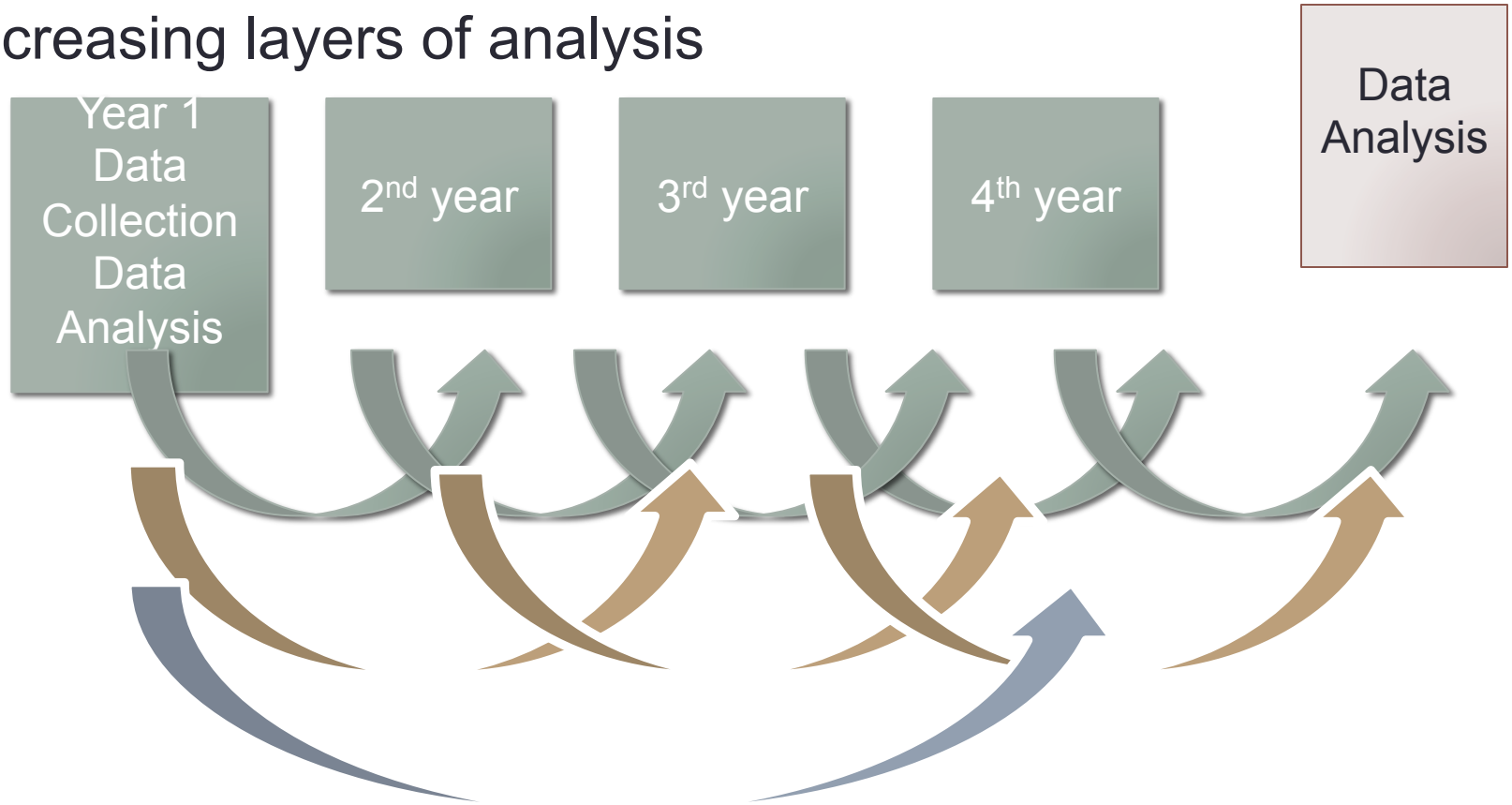
- Elementary vs. middle school at the transition from grade 4 to grade 5
  - Less flexibility in middle school schedule for students to miss part of a class session.
  - Research team must work with several teachers to coordinate for research visits in middle school for grade 5.

Staffing challenges

- Turnover of Graduate Research Assistants (GA s)
  - Participants stayed in the project *longer* than the research team members (GA s)
    - None of the GA s could follow a single student completely throughout four years.
  - New GA s were needed later in the project to conduct teaching episodes, to master the LTs, and to manage data.
    - This is a cost that accumulates, as the new staff must incorporate the expertise and analytical insights of the prior staff into their ongoing work.
    - A new GA must catch up to what had come before and then carry on with immediate data collection.
    - Stepping into the analysis of data requires knowledge of backlogged data while collecting new data.

Purposeful planning for extensive data analysis

- Data cascades into the latter years and requires increasing layers of analysis



Concurrent data collection and data analysis- a challenge

- Data collection is concurrent with the analysis of existing data that continually accumulates.
  - Stopping data collection systematically during each semester reduces the number of teaching data points with students, but does allow comprehensive documentation.
  - Because the data is cumulative, it makes sense to have more research analysts working during the latter part of the project (but we did not anticipate this!).

General challenge of analysis

- Dynamic constant comparative analysis
  - Your knowledge is changing during the period
  - By the time you finish, you have to start over with the analysis.
    - Our evolving ideas about trajectories were another challenge for us. How we looked at the video first year is different than how we looked in fourth year. The way we analyzed has been changed. Hence we needed to re-analyze the data we obtained in year 1 through the lens we had developed by year 4.
  - (Yet, you cannot go back for more clarification and elaboration)

Possible design change…

- In an ideal situation, we might first carry out a one year study (say with grade 2 students), then apply that analysis to improve our design of a second study with grade 2 again, now moving on to grade 3…

(looping back through what we learned about working with grade 2 students, while extending into work with grade 3 students).

- This would eventually produce a recursively-linked sequence of longitudinal studies of a developmental span on a given topic.

Summary of Recommendations

- Need for further longitudinal work
  - To conduct effective evaluations of existing learning trajectories, or to examine the coherence of research frameworks that address development of thinking and strategies in school children, there is a need for long-term studies.
- Contingencies and Dynamic staffing
  - Plan for attrition of subjects
  - Set up redundancy and **purposeful overlapping** of research staff (GA s).
  - Expect your data set to grow, while your staff does not, requiring increasing layers of analysis after the first two years.
  - Plan for expanding analysis capacity (GA staff) during the final year (last stage).
  - Need for administrative staff person other than GAs to manage data storage and access.

Further benefits (data sets)

- The accumulation of a systematic set of videotaped interviews on a focused domain (measurement of length, area and volume) with case study students.
- These interviews were coded in Nvivo (database software) by constructs from the LT s such as unit, or iteration.
- This library supports professional development aimed at the use of Learning Trajectories as guides for teachers to carry on formative assessment with students in these grade levels (PreK to Grade 5).
- This project has supported the training of several researchers who worked as graduate researchers.
- Finally, our team has contributed to the Mini-center on Measurement centered at Michigan State University (J. Smith).