Designing Learning Environments to Foster Productive and Powerful Discussions among Linguistically Diverse Students in Secondary Mathematics

William Zahner
San Diego State University

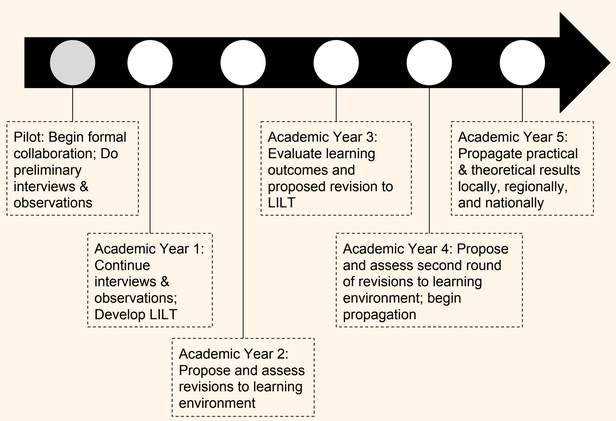
Introduction & Framing

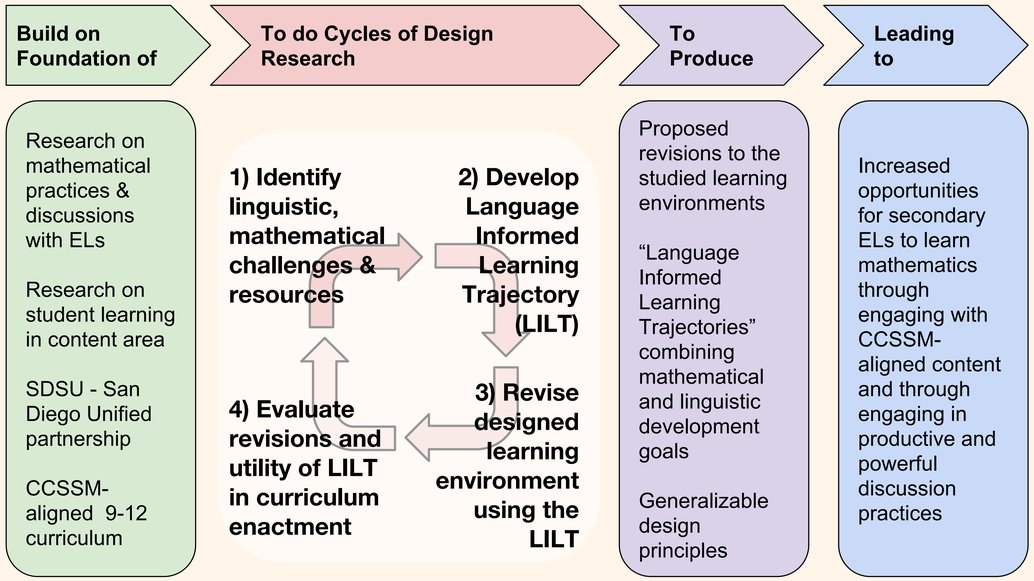
- Teachers of English Learners (ELs) must develop students' mathematical proficiency while building their academic language (Khisty, 1995; Moschkovich, 2015).
- Prior research provides guidance on developing academic language (e.g., Schleppegrell, 2010); a distinct body of work focuses on developing specific mathematical concepts (e.g., Lobato, Ellis, Muñoz, 2003)
- This project is developing a new framework that explores intersections of content-focused mathematics education research and EL-focused research. Initial content focus: linear and exponential rates.

Research Questions

1. What linguistic and mathematical challenges do ELs face when solving problems about and modeling with linear functions?
2. What resources do ELs access when solving problems about and modeling with linear functions?
3. How can a Hypothetical Learning Trajectory in the area of modeling with linear functions be redesigned to minimize challenges for ELs and build upon ELs' resources?

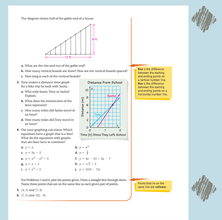
Project Timeline





Pilot Work Example: Identifying **Challenges** and **Resources** in One Problem About Slope

- The curriculum introduces slope-as-rate with problems about the steepness of a roof.
- Problems about roof steepness then appear 6 distinct times in the text.



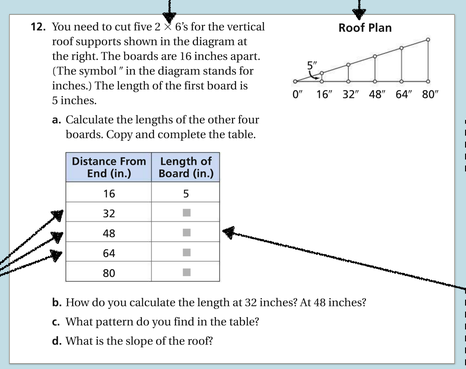
- The following linear pattern review problem appeared in the chapter where students compare linear and exponential growth.
- 10 students (5 ELs) were asked to solve the problem

Challenges

"2 x 6's" and the symbol " seemed to cause unnecessary linguistic challenge. Suggestion: consistently use "board" and the abbreviation "in." to remove unneeded complexity.

Two students attempted to find slant distances, instead of vertical lengths.

With the equally spaced inputs, most of this problem could be solved correctly using only additive reasoning, not slope.



Resources

One student referred to his experience with construction to understand problem context.

Most students successfully used recursive reasoning on the table.

Two students made connection to "input-output" tables from functions chapters.

One student used covariational reasoning to generalize a function rule and find board heights for values not on the table (e.g., at 41 in.).

Design Cycles

- Project is based on principles of design research (Cobb, Confrey, DiSessa, Lehrer, & Schauble, 2003).
- The mathematical focus is understanding and modeling with linear and exponential functions (Common Core State Standards F-LE.A.1a-c and F-LE.A2).
- Partnering school uses the NSF-funded curriculum CME Integrated Mathematics (Cuoco & Kerins, 2013), a CCSSM-aligned curriculum.

Data & Methods

Setting	Urban high school 30% ELs and 50% former/reclassified ELs
Participants	9th graders drawn from two classes
Problem Solving Interviews	Semi-structured clinical interviews focused on key problems from textbook related to rates
Interview Analysis	Modified grounded approach: **Challenges** identified in reading fluency and questions probing student interpretation of problems **Resources** identified in tools and connections students used to access problems
Additional Observations	Interviews triangulated with classroom observations

References

Cobb, P., Confrey, J., DiSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. Educational Researcher, 32, 9–13.
Cuoco, A., & Kerins, B. (2013). Integrated CME project. Boston, Mass.; Newton, Mass.: Pearson ; Education Development Center.
Khisty, L. L. (1995). Making inequality: Issues of language and meanings in mathematics teaching with Hispanic students. In W. G. Secada, E. Fennema, & L. B. Adajian (Eds.), New directions for equity in mathematics education (pp. 279–297). Cambridge, UK: Cambridge University Press.
Lobato, J., Ellis, A., & Muñoz, R. (2003). How "focusing phenomena" in the instructional environment support individual students' generalizations. Mathematical Thinking and Learning, 5, 1–36.
Moschkovich, J. N. (2015). Academic literacy in mathematics for English Learners. The Journal of Mathematical Behavior. http://doi.org/10.1016/j.jmathb.2015.01.005
Schleppegrell, M. (2010). Language in mathematics teaching and learning: A Review. In J. N. Moschkovich (Ed.), Language and mathematics education: Multiple perspectives and directions for research (pp. 73–112). Charlotte, NC: Information Age Publishing, Inc.

San Diego State University

Support for this work was provided by The University Grants Program at San Diego State University and by National Science Foundation Award No. 1553708. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of San Diego State University or the National Science Foundation.