

Learning Trajectories in Grades K-2 Children's Understanding of Algebraic Relationships

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Algebra is a central concern in school mathematics education. Its historical gatekeeper role in limiting students' career and life choices is well documented. In recent years, the response has been to reframe algebra as a K-12 endeavor. To this end, research on children's algebraic thinking in grades 3-5 shows that students can begin to understand algebraic concepts in elementary grades that they will later explore more formally. However, there is much that is unknown about how children in grades K-2 make sense of algebraic concepts appropriate for their age. This project aims to understand specific ways in which grades K-2 children begin to think algebraically. It will identify how children understand mathematical relationships, how they represent the relationships they notice, and how they use these relationships as building blocks for more sophisticated thinking.

The project will use classroom-based research to teach children about important algebraic concepts and to carefully explore how children come to understand these concepts. The primary goal is to identify levels of sophistication in children's thinking as it develops through instruction. Understanding how children's thinking develops will provide a critical foundation for designing curricula, developing content standards, and informing educational policies, all in ways that can help children become successful in algebra and have wider access to STEM-related careers.

While college and career readiness standards point to the role of algebra beginning in kindergarten, the limited research base in grades K-2 restricts algebra's potential in K-2 classrooms. This project will develop cognitive foundations regarding how children learn to generalize, represent, and reason with algebraic relationships. Such findings will inform both the design of new interventions and resources to strengthen algebra learning in grades K-2 and the improvement of educational policies, practices, and resources. The project will use design research to identify:

1. learning trajectories as cognitive models of how grades K-2 children learn to generalize, represent, and reason with algebraic relationships within content dimensions where these practices can occur (e.g., generalized arithmetic);
2. critical junctures in the development of these trajectories; and
3. characteristics of tasks and instruction that facilitate movement along the trajectories.

The project's design will include the use of classroom teaching experiments that incorporate: (1) instructional design and planning; (2) ongoing analysis of classroom events; and (3) retrospective analysis of all data sources generated in the course of the experiment. This will allow for the development and empirical validation of hypothesized trajectories in students' understanding of algebraic relationships. This exploratory research will contribute critical early-grade cognitive foundations of K-12 teaching and learning algebra that can help democratize access to student populations historically marginalized by a traditional approach to teaching algebra. Moreover, the project will occur in demographically diverse school districts, thereby increasing the generalizability of findings across settings.

