Improving Children’s Understanding of Mathematical Equivalence

Who Conducts the Research?

Prof. Nicole McNeil is the ACE Associate Professor of Psychology at the University of Notre Dame. She is the Director of the Cognition, Learning, and Development Lab at Notre Dame. She also directs Notre Dame’s Interdisciplinary Minor in Education, Schooling, & Society. She studies the development of mathematical thinking and is a nationally recognized scholar at the intersection of cognitive development and mathematics education. She has been awarded three major federal grants: two from the US Department of Education’s Institute of Education Sciences and one from the National Science Foundation. In 2008, she was awarded the Presidential Early Career Award for Scientists and Engineers, which is the highest honor an early career scientist or engineer can receive from the U.S. Government.

Prof. McNeil’s research team includes teachers from around the country along with research specialists, graduate students, and undergraduate students at Notre Dame. The two primary teacher collaborators who have helped develop the CLAD Math intervention are Julia Matthews and Heather Brletic-Shipley. Ms. Matthews received her Master’s degree in special education from Vanderbilt University. Ms. Brletic-Shipley is a National Board Certified teacher with 16 years of teaching experience. In 2008, she was recognized as one of the top ten teachers in the state of North Carolina.

The Focus: Children’s Understanding of Mathematical Equivalence

Understanding of math equivalence involves several related skills:

- Interpreting the equal sign as relational symbol
- Reading and encoding the structure of equations correctly
- Noticing relations among expressions in equations
- Correctly identifying and equalizing the two sides of an equation

Why We Care

Math equivalence is widely regarded as one of the most important concepts for developing young children’s algebraic thinking, and success in algebra determines children’s future educational and employment opportunities. Math equivalence is a “big idea” that is central to the learning of mathematics. Indeed, children’s understanding of math equivalence in symbolic form (as measured by our tasks) is a strong predictor of their general math achievement. In a recent study, we found that it predicted math achievement on all three subsections of the WJ (a widely-used standardized math test), even after controlling for several other factors. We found that it predicted math achievement better than IQ, free/reduced lunch status, race/ethnicity, gender, and understanding of math equivalence in concrete form.

Disheartening Statistic

Only ~20% of children in the U.S. between the ages of 7-11 demonstrate adequate understanding of this fundamental concept, whereas over 90% of first graders in China do.
Our Research

The CLAD Math intervention is part of an ongoing research project funded by the U.S. Department of Education’s Institute of Education Science (IES). Previous research has suggested that a lack of readiness for algebra can be traced back to misconceptions about mathematical equivalence that children construct from their early experiences with arithmetic in elementary school. We hypothesize that these misconceptions can be reduced with small modifications to traditional arithmetic practice. Thus, we are designing and testing a modified form of arithmetic practice. The goal is to improve children’s understanding of important math concepts, such as mathematical equivalence, while also promoting computational fluency.

In 2007, our team was awarded our first IES grant to examine if children benefit from modified arithmetic practice. We met one-on-one with 2nd and 3rd grade children and tested the effects of various modifications to arithmetic practice. We used the results from these sessions to design our first version of the CLAD Math workbook. We then randomly assigned students in several second grade classrooms to use either our modified workbook or a comparable traditional workbook. We found that compared to students who used the traditional workbook, the students who used the modified workbook gained better conceptual understanding of math equivalence and similar computational fluency.

In 2011, our team was awarded a second IES grant to build upon the success of our first grant. The goal of this new project is to examine if children’s conceptual understanding of math equivalence and computational fluency can be further improved by making additional modifications over and above the modifications we previously made. Teachers in the study will be randomly assigned to use either the original version of CLAD Math (which was already shown to improve children’s understanding), or the new version, so we can see which version is most beneficial. At the completion of the study, if one version is shown to be superior than the other, then all teachers will receive copies of the most beneficial version to use with their class. By participating in this study, teachers not only receive an evidence-based intervention that will facilitate their students’ understanding of important math concepts, but get to help us with the critical step of turning research into practice!

Proposed Schedule

CLAD Math consists of 32 sessions. We designed each session to last approximately 15 minutes. Our suggested schedule is two CLAD Math sessions per week for a total of 16 weeks.

Assessment

In order to determine the effectiveness of CLAD Math, students complete a pretest and posttest. We encourage teachers to reflect on the strengths, weaknesses, and any difficulties they perceive during implementation of a session. Additionally, at the midpoint and endpoint of the study, we will ask teachers to complete a survey and brief phone interview to help us assess the feasibility and usability of the intervention.

Important Note

CLAD Math should be used as a SUPPLEMENT teachers’ regular math curriculum. It is not intended to replace or alter their regular math lessons. Teachers will continue to teach their regular math lessons as they normally would. They will be instructed to use CLAD Math 2 times per week for ~15 minutes each day during free times in their classroom schedules, or during times that they would usually reserve for “arithmetic practice” or “enrichment” activities.