The Development of Storybooks Supporting Elementary Students' Math Identity, Executive Function, and Word Problem Solving

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Background

- Executive function (EF) skills and mathematics skills are related.[1]
- Math self-concept is linked to math achievement,[2] and students' mathematics vocabulary also predicts math achievement.[3]
- To achieve racial and socioeconomic equity in math education, there is a critical need to help students, particularly Black and Latine/x students and students experiencing poverty, build strong identity and agency in math while using an instructional approach that supports EF skills.[4, 5]
- Our team created Our Mathematical World (OMW), a nine-week curriculum overlay with a sequential set of activities designed to center students as strong math problem solvers who intentionally use EF skills.
- Central to OMW is a book series showcasing PULSE (Pause, Understand and Remember, Lay It Out, Solve, Evaluate), a project-specific metacognitive approach that integrates EF and problem-solving skills.

Method

Participants:

- *N* = 111 students from 8 classrooms at one school in the Western U.S. (18 3rd grade, 39 4th grade, 34 5th grade, 20 7th grade); 52% female; 75% Latine/x, 10% Asian, 7% Multiracial; 50% highest caregiver education a high school diploma or less
- *N* = 7 teachers (3 from the OMW co-design team); 71% female

Measures:

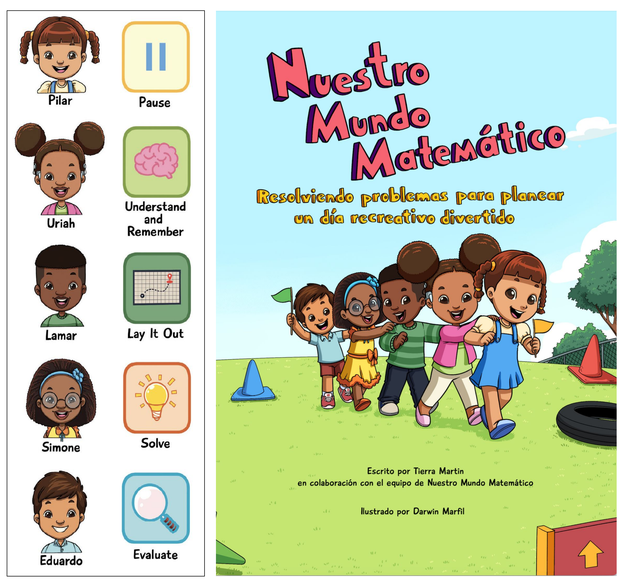
- Students completed pretest and posttest measures of math identity, EF, problem solving, and math vocabulary (administered by researchers).
- After the program, a subset of students (*N* = 42) answered questions about their experience with OMW.
- Teachers completed brief surveys after implementation of each book and at the end of the entire program.

Book #	Title	PULSE Focus	Example Problem
1	Pilar Pauses to Solve Problems	(P) Take a deep breath and focus	25 + ? = 48
2	Uriah Understands and Lamar Lays Out a Plan	(U) Read the problem and keep information in mind. (L) Create a plan.	36 / 6 = ?
3	Simone Solves and Eduardo Evaluates	(S) Find a solution. (E) Does the solution make sense?	750 / 50 = ?
4	Problem Solving with Sweet Treats	Entire PULSE approach	4 x ½ = ?
5	Solving Problems to Plan for Field Day Fun	Entire PULSE approach	600 / 5 = ?

Storybook Development

- Each book was co-designed by educators, students, and researchers.
- Each book features Black and Latine/x youth engaged in math problem-solving in different community contexts (e.g., food drive).
- Our team consulted with a children's book author to create the initial storyline and math focus, increasing in difficulty across the series.
- After initial co-design, books were translated to Spanish by scholars representative of different Latine/x communities.
- Books were piloted in multiple phases, and we used both teacher and student feedback to improve the books (e.g., character names, exact text per page, and illustrations) before the 2022-2023 pilot year.

An example sequence of iterations in book development from *Book 3: Simone Solves and Eduardo Evaluates.*



The PULSE approach included at the beginning of each book (left); The Spanish cover for Book 5 (right).

Results

Direct Assessments (Pre-to-Post Paired Samples T-Tests)

- *Math Identity*: Math in my Environment (*N* = 93, *d* = 0.33), other scales n.s.; decreases in math identity observed across grades
- *Executive Function*: Hearts & Flowers (*N* = 73) *d* = 0.21, Even & Odd (*N* = 66) *d* = 0.26, Wisconsin Card Sort (*N* = 63) *d* = 0.25; other 3 tasks n.s.
- *Problem Solving* (*N* = 89): *d* = 0.26; *Math Vocabulary* (*N* = 87): *d* = 0.66

Student Feedback

- Survey items 0 = No, 1 = Not Really, 2 = Kind of, 3 = Yes
  - "Reading the OMW books made me feel like a strong math learner." (*M* = 2.15, *M* = 2.07, *M* = 1.13 for 4th, 5th, & 7th graders)
  - "I liked the books." (*M* = 2.69, *M* = 2.00, *M* = 1.33 for 4th, 5th, 7th)

Teacher Feedback

- "The best part is how focused [the students] are and how much they enjoy solving the problems before we get to the next page and the answer." - 4th grade teacher, new to OMW
- "I enjoy the books. [...] The students have come to recognize the characters throughout the story series." - 7th grade teacher, OMW team

Discussion

- Students demonstrated positive pre-to-post change in seeing math in their environment, EF, problem solving, and math vocabulary skills.
- Qualitative results from teacher interviews and student surveys complemented quantitative results indicating program effectiveness.
- Student feedback suggests adaptations are needed for older grades.
- Future research is needed to examine the benefits of each component of OMW (books and the math identity, EF, and problem solving lessons).

References

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