

THE DEVELOPMENT AND EVALUATION OF A FAMILY-CENTERED PICTURE BOOK INTERVENTION FOR EARLY MATH LANGUAGE

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Purdue Early Achievement Research Labs



THANKS TO MY COLLABOR ATORS!!!













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<u>Me</u>

Using our knowledge of basic processes and family interactions to build and evaluate interventions that support math development through high-quality parent-child interactions

OVERVIEW

Background on home engagement and math Language

- Part 1 Intervention Development and Refinement Process
 - Book Development
 - Book Refinement
 - Piloting
- Part 2 Randomized control trial of the intervention
- Next Steps

BACKGROUND

- Parent-child home engagement in educational activities is important for children's academic development
 - One of the most common home engagement activities is reading...



BACKGROUND

- Parent-child reading differs in frequency for general reading versus math/number book reading (Lin, Litkowski, Schmerold, Elicker, Schmitt, & Purpura, 2019).
 - Reading general books occurs a few times a week to nearly every day
 - Reading math/number books occurs a few times a month to once a week

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- Why?

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- Illustrations in some books may make engaging in math activities more challenging (Ward, Mazzocco, Bock, & Prokes, 2017)
- Most books focused on math are not engaging (My Kids, 2012, 2014, 2016a, 2016b)
 - No storyline, no consistent characters, little engagement for repeated reading



THE POTENTIAL FOR PICTURE BOOKS...

- Picture book reading can be a potential context for engaging children in math
 - Preschool teachers (Piasta et al., 2014) and parents of preschool children (Thompson, Napoli, & Purpura, 2017) engage in very limited math activities with their children.
 - Reading picture books occurs frequently in school and at home and has been demonstrated to be a tool for improving mathematics (Anderson et al., 2005; Casey et al., 2004; Hojnoski et al., 2014; Jennings et al., 1992; Young-Loveridge, 2004)

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 - Reading picture books occurs frequently in school and at home and has been demonstrated to be a tool for improving mathematics (Anderson et al., 2005; Casey et al., 2004; Hojnoski et al., 2014; Jennings et al., 1992; Young-Loveridge, 2004)
- One particular aspect of mathematics that may be supported through picture book reading is mathematical language (Purpura, Napoli, Wehrspann, & Gold, 2017)

- Early math involves specific math language (Purpura & Reid 2016)
 - Need to know quantitative and spatial mathematical terms
 - Quantitative: more, less, fewer, a lot, some
 - Spatial: before, after, near

Math Language = key terms and concepts (e.g., more/most)

Numeracy skills = counting, numeral identification, addition/subtraction



SIMILAR NOT SAME



- Math language is:
 - More proximal to math performance than is general language (Hornburg, Schmitt, & Purpura, 2018; Purpura & Reid, 2016; Toll & van Luit, 2014a)

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- A better risk classifier of later math difficulties than is initial math performance (Purpura, Day, Napoli, & Wehrspann, 2017)
- Improving math language also results in improved numeracy skills (Purpura, Napoli, Wehrspann, & Gold, 2017)

DEVELOPING A FAMILY-CENTERED MATH PICTURE BOOK INTERVENTION

...designed to improve math language and language

FOUR PHASE INTERVENTION DEVELOPMENT

- 4-year project funded by the Heising-Simons Foundation
 - Develop, pilot, evaluate, and disseminate a family-centered picture book intervention



2016-2017 Book Development

2017-2018

Piloting of Intervention and Development of Training Materials 2018-2019 Evaluation of Intervention Effects

through two RCTS

2019-2020 Dissemination

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Four key components to the book development process:

Empirically grounded book design

- Design of books both a science and an art
 - Professional illustrator and author

REASONS FOR A PROFESSIONAL ILLUSTRATOR



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REASONS FOR A PROFESSIONAL AUTHOR

- The story writing process is phenomenally complex
 - Characters must have depth, but stay consistent across stories
 - There must be an engaging story arc (both internal and external)
 - Page turns...the story needs to draw families in to turn the page
 - Language must be appropriate for target age

REASONS FOR A PROFESSIONAL AUTHOR

- Attention to industry standards
 - Typically 32 total pages including cover and back (~12 spreads)
 - Text length: ~250-350 words for preschool age books
 - Every word counts!
 - Harder to write than we would expect

 Not attending to these issues may limit distribution of books eventually or increase costs

- Design of books both a science and an art
 - Professional illustrator and author
 - Text on one page, picture on other page (Flack & Horst, 2018)





Benjamin carefully measured the milk. They had just enough to match the recipe.

"Yay!" Lucy cheered.

CRACK

Some of the eggs were broken.

"Oops!" said Lucy. "Now there are not enough eggs."

1. Why aren't there enough eggs?

2. Do they have more cups of sugar or more cups of milk?

3. Now they have a different number of eggs as the recipe. How can they have the same amount?



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Design of books – both a science and an art

- Professional illustrator and author
- Text on one page, picture on other page (Flack & Horst, 2018)
- Illustrations provided opportunities for counting, comparing, adding, etc.
 - Clear countable sets to avoid counting confusion (Ward et al., 2017)
CLEAR COUNTABLE SETS

Ward et al., 2017



CLEAR COUNTABLE SETS



CLEAR COUNTABLE SETS



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Empirically grounded book design Developed in English and Spanish

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 - Availability of picture books in Spanish is low
 - Quality of books and translation is often less than ideal
 - Cost is higher than the same book in English

Best Seller



The Very Hungry Caterpillar

by Eric Carle | Mar 23, 1994

Board book \$5⁹¹

✓prime Get it as soon as Sun, Nov 17
FREE Shipping on orders over \$25 shipped by
Amazon

More Buying Choices \$1.00 (248 used & new offers)

Audible Audiobook

\$**0**00 \$7.00

Free with Audible trial

Kindle

\$9⁹⁹ \$10.00

Other formats: Hardcover, Audio CD,



La oruga muy hambrienta/The Very Hungry Caterpillar: bilingual board book by Eric Carle | May 12, 2011

★★★★☆ ~ 119

Board book

\$8⁶⁶ \$10.99

✓prime Get it as soon as Sun, Nov 17
FREE Shipping on orders over \$25 shipped by
Amazon

More Buying Choices \$2.33 (66 used & new offers)

- Development in English and Spanish
 - Dialect neutral
 - Gendered language
 - Word difficulty/language differences

CHALLENGES IN TRANSLATION

- Spanish
 - Most
 - La mayoria, la mas

Four key components to the book development process:

Empirically	Developed in
grounded book	English and
design	Spanish
Math language integrated into pictures and text	

Book 1: Greater



Book 2: Equivalence



Book 3: Fewer









 Use of dialogic reading prompts (Arnold & Whitehurst, 1994; Lonigan et al., 1999)

Empirically	Developed in
grounded book	English and
design	Spanish
Math language integrated into pictures and text	Built-in Prompts

"I packed a lot of pillows," Benjamin said. "I don't want the ground to be hard."

"Bear and I packed pillows too!" said Lucy.

Bear had a pillow. Lucy had more pillows. Benjamin had the most pillows.



1. Who has more pillows: Bear or Benjamin?

2. Benjamin likes to sleep with a lot of pillows. What do you like to sleep with?

3. Why doesn't Bear need as many pillows as Lucy or Benjamin?



RESULTS



FRAMEWORK FOR NEW INTERVENTION

- 4-year project funded by the Heising-Simons Foundation
 - Develop, <u>pilot</u>, evaluate, and disseminate a family-centered picture book intervention
 - Obtaining <u>systematic</u> and <u>direct feedback</u> from a diverse group of parents



2016-2017 Book Development

2017-2018 Piloting of Intervention and Development of Training Materials 2018-2019 Evaluation of Intervention Effects through two RCTS 2019-2020 Dissemination

TWO PHASE PILOTING

Phase 2a – Book Refinement

 Single-visit reading of books to obtain feedback on the books and dialogic reading prompts

Phase 2b – Intervention Refinement

 Full implementation of intervention with families to obtain feedback on the intervention process and evaluate differences in instructional intensity.

Goal: Obtain initial feedback on the design and development of the books.

10 total parent-child dyads

- Five monolingual English speakers
- Five bilingual/monolingual Spanish speakers

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- Key points of positive feedback from parents:
 - Text-picture match
 - Books held attention
 - Questions helped with storyline and engagement
 - Books were highly enjoyable for parent (8.5/10) and child (8.2/10)

PHASE 2A – THINGS WE LEARNED

- Key constructive feedback from parents:
 - Refinement of text and questions
 - Improved instructions page
 - Particular types of examples parents would benefit from seeing in training
 - Bilingual versions of books rather than Spanish versions

FFFFPT

"¡Oh no!" lloró Lucy. "El pastel está arruinado." "Está bien," dijo Benjamín. "Podemos hacer otro pastel juntos."

1. ¿Por qué está arruinado el pastel?

- 2. ¿Qué pasará cuando Lucy y Benjamín hagan otro pastel?
- 3. ¿Qué se le olvidó a Lucy ponerle al pastel?

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FFFFPT

"Oh no!" Lucy cried. "The cake is ruined."

"It's alright," said Benjamin. "We can bake another cake together."

Why is the cake ruined?
 What will happen when Lucy and Benjamin bake another cake?
 What did Lucy forget to put in the cake?

PHASE 2B – INTERVENTION REFINEMENT

- Goal: Obtain feedback from parents on the intervention process including fidelity, growth in knowledge, and feasibility.
 - Also test the level of parent training intensity needed to generate positive growth on outcome variables.

PHASE 2B - INTERVENTION REFINEMENT



PHASE 2B - TRAINING



Attention Readers!

Kids learn more and have more fun when they get involved in story time. Make reading a conversation with your children! Here are some tips:

1. Ask one question per page.

Red questions for 1st reading Blue questions for 2nd reading Purple questions for 3rd reading After the third reading, use any question or make up your own!

2. Keep the conversation going.

Be flexible! Build on what your child says and relate the conversation to his or her interests.

3. Have fun!

PHASE 2B - INTERVENTION PROCESS



You will get two weekly reminders about your readings, and we will check in with you at the end of each week with a brief survey!

PHASE 2B – PILOT FINDINGS

Multi-method fidelity collection

- Weekly Qualtrics surveys and audio recording of sessions using a USB audio recorder.
- Total number of readings
 - Parents reported completing, on average, 10.5/12 readings
 - 56% of parents reported completing all 12 readings
 - 81% of parents reported completing at least 10 readings

PHASE 2B – PILOT FINDINGS

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• Using Dialogic reading prompts

- 94% of the time parents reported reading all or most of the designated questions
- 64% of the time parents reported reading more than just the designated question at least for some pages

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Engagement/Enjoyment

- On a scale of 1 (lowest) to 10 (highest) parents reported that their children highly enjoyed reading the books (8.5/10)
 - Enjoyment level was consistent across all four weeks (8.6, 8.6, 8.3, 8.5)








PHASE 2B – THINGS WE LEARNED

- Brief training is needed to generate effects on math language, but may not be necessary to improve numeracy
- Multi-method fidelity collection resulted in more complete fidelity data than either alone
- Parent feedback in the development process is extremely useful

PHASE 3 - EVALUATION

- 4-year project funded by the Heising-Simons Foundation
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PART 3

Randomized Control Trial to evaluate the effects of the intervention on children's math language and numeracy skills.

INTERVENTION MATERIALS

Quantitative Language Books





Book 2: Equivalence



Book 3: Fewer



ACTIVE CONTROL MATERIALS

Comparison books

- Do not contain quantitative or spatial language
- Somewhat cover topics of bike safety, bedtime routine, and sharing
- Illustrations originally from the Narrative Assessment Protocol developed at Michigan State University (Ryan Bowles)







INTERVENTION PROCESS



PARTICIPANTS

84 participating families

- Adults: 75 mothers, 5 fathers, 3 grandparents, 1 others
 - Median education, Bachelor's degree
- Children:
 - 3.03 to 5.31 years old (M = 4.14, SD = 0.61)
 - 40 female, 44 male
 - 76.1% Caucasian, 1.2% Hispanic, 4.8% African American, 2.4% Asian, 14.3% multi-racial, 1.2% did not report

PRELIMINARY ANALYSES

Attrition

- 6 families did not attend visit 2
- 4 families did not attend visit 3

Dosage

- On average, parents reported reading to their children for 10.69 sessions (out of 12)
 - 81% of families in the intervention group read at least 10 times
 - 74% of families in the control group read at least 10 times

Child Enjoyment

 Parents reported that their children really enjoyed the books (~8.5/10)

ANALYTIC PROCEDURE

Four regression analyses

- Math language: posttest, delayed posttest
- Numeracy: posttest, delayed posttest
- Covariates
 - Pretest scores on: math language, numeracy, vocabulary, attentional flexibility, sex, age, parent education, and dosage

INTERVENTION EFFECTS – MATH LANGUAGE



INTERVENTION EFFECTS - NUMERACY



- Were the intervention effects different depending on:
 - Initial math language
 - Initial numeracy
 - Age
 - Parental education
 - Dosage
 - Sex

- Were the intervention effects different depending on:
 - Initial math language 💥
 - Initial numeracy 🗱
 - 🛚 Age 💥
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 - Dosage 🗱
 - Sex 🗱

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 - Dosage 🗱
 - Sex 🗱
 - Parent math anxiety

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CONCLUSIONS

- The brief intervention has immediate effects at posttest on both math language and numeracy skills; however, the effects on math language decrease, but are still practically important 8 weeks later
- Effects were not dependent on a range of possible moderators
- Parents exhibited high levels of implementation fidelity (dosage)
- This was an easy to use process for parents and their children enjoyed it

NEXT STEPS

- Examine audio recordings to measure implementation fidelity
 - Engagement, use of dialogic reading prompts, parent and child use of numeracy, etc.
- Finish other RCT with Spanish-English dual language learners
- Finish development of spatial language books and patterning books
- Expand the series of books to include a broader range of math foci
- Explore additional tools (e.g., e-books, animated shorts) for supporting learning
- Dissemination of materials to parents and schools

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