A Longitudinal Randomized Trial of a Sustained Content Literacy Intervention from First to Second Grade: Transfer Effects on Students’ Reading Comprehension

Online Supplementary Materials

**Supplementary Materials S-A**

Table S-A

*Modifications to Original Design for the MORE Intervention.*



*Figure 1*. Actual plan for MORE sustained content literacy intervention from first to second grade.

\*Control group for Grade 1 students in School B in Grade 1

\*\*Control group for Grade 2 students in School A in Grade 2

*Note*. Strikethrough indicates research plan that was not implemented due to school closures in spring 2020. \*Control group for Grade 1 students in School B in Grade 1. \*\*Control group for Grade 2 students in School A in Grade 2. MORE = More of Reading Engagement.

Table S-A visually displays the original research plan as well as the modified plan to adjust to the school closure situation. The original plan was to follow the Grade 1 treatment group children into Grade 2 and Grade 2 treatment children into Grade 3 to focus on the sustained effects of the intervention over time. The final spring 2020 MORE lessons were to occur in both science and social studies units. The spring 2020 intervention core components was designed to be identical to spring 2019 implementation except that new topics were selected for the lessons in science and social studies. The statistical models were originally designed as individual growth models to account for repeated measures across the 12-month period, including four waves of a standardized domain-general reading comprehension assessment (i.e., Measures of Academic Progress [MAP]) given before and after lesson Grade 1 lesson implementation in school year 2018-2019 and before and after Grade 2 lesson implementation in school year 2019-2020. In the piecewise linear growth models, our first aim was to examine the impact of Grade 1 lessons followed by wide reading of thematically related informational texts over the summer on reading growth across three time points on the domain-general reading comprehension measure (MAP). Our second aim was to examine the impact of the full sequence of Grade 1 lessons, summer support for reading, and Grade 2 lessons on reading growth across four time points.

The assessment administration plan was affected by school closures in late spring 2020, but the first two waves of the assessment were successfully completed during the spring 2019 data collection and those results have been reported in a published study (Kim, Relyea, Burkhauser, Scherer, & Rich, 2021).

However, as the second round of implementation in spring 2020 was about to occur for Grade 2 and Grade 3 children who had moved from Grade 1 and Grade 2, respectively, the COVID-19 pandemic triggered school closings in our study site. Accordingly, modifications had to be made to our original plan on lesson implementation, post-test assessment, and data analytic approach, as shown in Table S-A. Specifically, in the treatment classrooms of Grade 2 and Grade 3, teachers delivered science unit lessons but were unable to implement the subsequent social studies unit. In terms of post-tests, we administered two sets of assessment to Grade 2 students: researcher developed measures of (a) science vocabulary knowledge depth test and (b) transfer tests of science content reading comprehension. None of the assessments were given to Grade 3 students due to the incompletion of the science thematic lessons and assessments.

We adjusted our plans to evaluate fidelity of lesson implementation by conducting teacher surveys instead of classroom observation. In short, due to the COVID-19 impact on data collection, available data allowed us to examine effects of the 12-month Grade 1 to Grade 2 intervention on growth in domain general reading comprehension (research question 1) and impact on spring Grade 2 science vocabulary knowledge and transfer effects on science content comprehension outcomes (research question 2 and 3).

**Supplementary Materials S-B**

Table S-B.1

*List of Informational Science and Social Studies Books Used in Grade 1 Treatment and Control Conditions*

|  |  |  |
| --- | --- | --- |
| Domain | Treatment | Control |
| Science | * *Ultimate Ocean Rumble*
* *Polar Bear vs Grizzly Bear*
* *Desert Animal Adaptations*
* *Rhino Rescue*
* *Killer Whale vs Great White Shark*
* *Penguins*
* *What was the Ice Age*
* *Desert Animal Adaptations*
 | * *Velociraptor*
* *Tacky the Penguin*
* *What If You Had Animal Teeth?*
* *National Geographic Readers: Great Migrations Whales*
* *National Geographic Readers: Sharks!*
* *Emperor Penguins*
* *Penny the Rude Penguin*
* *Bee*
* *Owls- National Geographic Kids*
* *Lions - National Geographic Kids*
* *National Geographic Kids - Sharks*
* *Night and Day*
* *What Makes Day and Night*
* *Why Do We Need Soil?*
* *Earth's Landforms and Bodies of Water*
* *Is All Soil the Same?*
* *Hawaii Volcanoes National Parks (Reading A to Z)*
* *Hummingbirds (Reading A to Z)*
* *Blue Whales: Giant Mammals (Reading A to Z)*
 |
| Social studies | * *You Wouldn't Want To Be A Viking Explorer*
* *Keep On!: The Story of Matthew Henson Co-Discoverer of the North Pole*
* *You Wouldn't Want To Be Lewis and Clark*
* *National Geographic Readers: Sacagawea*
* *You Wouldn't Want to Be a Polar Explorer*
* *The Inuit Thought of It*
 | * *Meet My Neighbor, The Dentist*
* *Goods and Services Around Town*
* *All Kinds of Homes (RAZ Kids)*
* *George Washington and the General's Dog*
* *George Washington Carver*
* *Epic Books My Itty Bitty Bio on Rosa Parks*
* *Epic Books My Itty Bitty Bio on Benjamin Bannekar*
* *Epic Books My Itty Bitty Bio on Howard Lewis Lattimer*
* *Epic Books My Itty Bitty Bio on Jackie Robinson*
* *President's Day*
* *A Day in the Life of a Garbage Collector*
 |

Table S-B.2

*List of Thematically Related Informational Print Books (N = 33) Read During Grade 1 Summer*

|  |  |  |  |
| --- | --- | --- | --- |
| Title  | Author | Lexile | Level |
| *Grade-level matched texts (choice of five books)* |  |  |  |
| *Who Would Win: Ultimate Ocean Rumble* | Jerry Pallotta | 680L | n/a |
| *Who Would Win: Lion vs. Tiger* | Jerry Pallotta | 640L | n/a |
| *Who Would Win? Tyrannosaurus Rex vs. Velociraptor* | Jerry Pallotta | 660L | n/a |
| *Who Would Win: Killer Whale vs. Great White Shark* | Jerry Pallotta | 620L | n/a |
| *Who Would Win: Hammerhead vs. Bull Shark* | Jerry Pallotta | 780L | n/a |
| *Who Would Win: Komodo Dragon vs. King Cobra* | Jerry Pallotta | 680L | n/a |
| *Who Would Win: Polar Bear vs. Grizzly Bear* | Jerry Pallotta | 720L | n/a |
| *Who Would Win: Whale vs. Giant Squid* | Jerry Pallotta | 700L | n/a |
| *Who Would Win: Tarantula vs. Scorpion* | Jerry Pallotta | 570L | n/a |
| *What if You Had Animal Feet?*  | Sandra Markle | AD950L | n/a |
| *What if You Had Animal Eyes?* | Sandra Markle | AD710L | n/a |
| *What if You Had T. Rex Teeth?* | Sandra Markle | AD630L | n/a |
| *What if You Had Animal Ears?* | Sandra Markle | AD630L | n/a |
| *Reader-level matched texts (choice of five books)* |  |  |  |
| *National Geographic Readers: Saving Animal Babies* | Amy Shields | 520L | med |
| *I Like Bugs* | Margaret Wise Brown  | BR 20L | low |
| *National Geographic Readers: Weird Sea Creatures* | Laura Marsh | NC 630L | med |
| *National Geographic Readers: Giraffes* | Laura Marsh | 420L | low |
| *National Geographic Readers: Cheetahs* | Laura Marsh | 580L | high |
| *Tigers at Twilight (Magic Tree House, No. 19)* | Mary Pope Osborne | 510L | high |
| *Fly Guy Presents: Sharks (Scholastic Reader, Level 2)* | Tedd Arnold | 540L | high |
| *Tyrannosaurus Rex (StoryBots) (Step into Reading)* | Storybots | 350L | low |
| *Big Shark, Little Shark (Step into Reading)*  | Anna Membrino | 150L | low |
| *What do you do with a tail like this?* | Steve Jenkins  | 510L | med |
| *Butterflies (Penguin Young Readers, Level 2)*  | Emily Neye | 460L | med |
| *National Geographic Readers: Swing Sloth!: Explore the Rain Forest* | Susan Neuman | 100L | low |
| *National Geographic Readers: Monkeys*  | Anne Schreiber | 590L | med |
| *National Geographic Readers: Sharks! (Science Reader Level 2)* | Anne Schreiber | 520L | high |
| *National Geographic Readers: Great Migrations Amazing Animal Journeys* | Laura Marsh | 810L | highest |
| *National Geographic Readers: Sacagawea (Readers Bios)* | Kitson Jazynka | 850L | highest |
| *National Geographic Kids Chapters: Rhino Rescue: And More True Stories of Saving Animals (NGK Chapters)* | Clare Hodgson Meeker | 780L | highest |
| *What Was the Ice Age? (Chapters 1-3)* | Nico Medina | 840L | highest |
| *Keep On! The Story of Matthew Henson*  | Deborah Hopkinson | AD1080L | highest |
| *Penguins and Antarctica: A Nonfiction Companion to Magic Tree House Merlin Mission #12: Eve of the Emperor Penguin* | Mary Pope Osborne | 700L | highest |

*Note*. n/a = non-applicable

Table S-B.3

*List of Thematically Related Digital Books (N = 6) Used for the MORE@Home App During Grade 1 Summer*

|  |
| --- |
| WOOP Book Title |
| How I WOOPED Life: The True Story of Basketball Superstar Jamarion Styles |
| How I WOOPED Life: The True Story of Supreme Court Superstar Sonia Sotomayor |
| How I WOOPED Life: The True Story of NFL Superstar and Math Whiz John Urschel |
| How I WOOPED Life: The True Story of NASA Superstar Katherine Johnson |
| How I WOOPED the 2008 Presidential Election: The story of how President Obama beat the odds and won North Carolina |
| How I WOOPED Life: The True Story of Harriet Tubman |

*Note*. WOOP = Wish, Outcome, Obstacle, and Plan. Both treatment- and control- Grade 1 students’ survey asked: *On the MORE @ Home app, there were 6 digital books you could read. About how many of these digital books did you read over the summer?*

**Supplementary Materials S-C**

**Table S-C.1**

*Results of Four-Level Piecewise Linear Growth Curve Modeling with Added Teacher-Level Random Effects for MAP Reading Comprehension, Vocabulary, and Reading Total (Reading Comprehension and Reading Vocabulary) Outcomes (N = 2,275)*

|  |
| --- |
|  |
|  | Model A:MAP Reading Comprehension | Model B:MAP Vocabulary | Model C:MAP Reading Total |
| Fixed Effects |  |  |  |
| Intercept | 170.74 (1.48)\*\*\* | 169.04 (1.40)\*\*\* | 169.41 (1.34)\*\*\* |
| Time 1 | 5.62 (.39)\*\*\* | 5.98 (.43)\*\*\* | 5.74 (.29)\*\*\* |
| Time 2 | 2.75 (.39)\*\*\* | 4.56 (.50)\*\*\* | 4.66 (.33)\*\*\* |
| Treatment | -1.81 (.65)\*\* | -.99 (.59)† | -.94 (.60) |
| Treatment  Time 1 | .95 (.52)† | -.144 (.57) | -.03 (.38) |
| Treatment Time 2 | 1.94 (.53)\*\*\* | 1.04 (.67) | .77 (.44)† |
| Variance Components |  |  |  |
| Level 1 (Time level) | 70.09 | 76.94 | 35.07 |
| Level 2 (Student level) |  |  |  |
| Intercept | 41.11 | 43.91 | 31.15 |
| Time Slope (Continuous) | 2.29 | 21.93 | 8.83 |
| Covariance | .31 | -13.17 | 1.22 |
| Level 3 (Teacher level) | 1.02 | 1.08 | 0.47 |
| Level 4 (School level) | 1.38 | .73 | 1.98 |
| Goodness of fit |  |  |  |
| Deviance (-2LL) | 48416.99 | 50006.21 | 45972.88 |
| Akaike information criterion | 48466.99 | 50056.21 | 46022.88 |
| Bayesian information criterion | 48636.41 | 50225.86 | 46192.53 |

*Note*. Student demographic characteristics (i.e., gender, race/ethnicity, grade, limited English proficiency/individual education plan status, socioeconomic status), Measures of Academic Progress (MAP) mathematics pretest scores, and school randomization blocks were included in the analyses as covariates but suppressed in Table S-C.1.

†*p* < .10, \*\**p* < .01, \*\*\**p* < .001.

**Table S-C.2**

*Results of Three-Level Hierarchical Linear Modeling for the Main Treatment Effects on Science Vocabulary Knowledge Depth and Science Content Reading Comprehension (N = 2,156)*

|  |  |
| --- | --- |
|  | Coefficient (*SE*) |
|  | Science content reading comprehension | Science vocabulary knowledge depth |
| Source | Overall | Near transfer | Mid transfer | Far transfer | Overall | Taught | Untaught |
| Fixed effects |  |  |  |  |  |  |  |
| Intercept | .04 (.16) | -.01 (.18) | -.06 (.17) | .19 (.17) | -.19 (.17) | -.256 (.17) | -.06 (.17) |
| Treatment  | .16 (.06)\*\* | .28 (.06)\*\*\* | .15 (.06)\*\* | .03 (.06) | .03 (.06) | -.03 (.06) | .11 (.06)† |
| Variance components  |
| Level 1 (Student level) | .54 | .75 | .65 | .67 | .6 | .64 | .67 |
| Level 2 (Teacher level) | .04 | .01 | .05 | .06 | .05 | .05 | .03 |
| Level 3 (School level) | .02 | .02 | .01 | .00 | .01 | .01 | .02 |

*Note*. Student demographic characteristics (i.e., gender, race/ethnicity, grade, limited English proficiency/individual education plan status, socioeconomic status), Measures of Academic Progress (MAP) reading and mathematics pretest score, and school randomization blocks were included in the analyses as covariates but suppressed in Table S-C.2.

†*p* < .10, \*\**p* < .01, \*\*\**p* < .001.

**Supplementary Materials S-D**

*Detailed information on Grade 2 Science Content Comprehension Passages and Items, IRT Analysis, and Factor Analysis*

**S-D.1. Grade 2 Science Content Comprehension Passages and Questions**

Teacher Directions to Read Aloud: “*Today, you will read this passage about paleontologists and the ammonites. Now you will read the passage silently by yourself and then answer the questions. There are 3 answer choices for each question but only one correct answer. Circle the answer that you think is correct. After question 7, stop and wait for your teacher to read the directions. You may begin.”*

**S-D.1.1. Near transfer passage: Paleontologists and the Ammonites**

1

There have been five mass extinctions in the earth’s history. What happened

during the fifth mass extinction nearly 66 million years ago? What species was

gone forever? Dinosaurs. What about fish in the oceans?

2

Paleontologists found a body fossil of a shellfish that became extinct long ago.

The shellfish is called an ammonite. Ammonites were predators that lived in the

ocean. They were related to other ocean predators like the octopus.

3

Ammonites survived for a long time. They had a strong shell that protected them

from large fish. They were also good hunters.

4

But there are no more ammonites living today. What happened? Paleontologists

have used fossil evidence to understand what happened in the past. Even 66

million years ago. One theory is that a huge rock from outer space killed many

plants and animals. Another theory is that ammonites had trouble finding food

before the huge rock hit the earth.

5

Body fossils help paleontologists understand what happened to living things in the

past. Even when no one was around to see the animals.

Questions

|  |
| --- |
| 1. According to the passage, who studies the fossils of ammonites?
2. paleontologists
3. predators
4. hunters
 |
| 1. This passage mainly tells about

the physical characteristics of ammonitesthe theories of the ammonite’s extinctionthe dinosaur extinction 66 million years ago |
| 1. Some paleontologists think
2. Ammonites became extinct before dinosaurs
3. Many animals die during a mass extinction
4. A big rock hit the earth and killed all the ammonites
 |
| 1. In paragraph 1, what does mass extinction mean?
2. A long time ago
3. Disappeared forever
4. All over the world
 |
| 1. A strong shell is an example of a living animal’s
2. Physical characteristic
3. Fossil evidence
4. Hunter behavior
 |
| 1. The author of this article wants you to learn
2. How paleontologists work together
3. How paleontologists study fossils
4. How paleontologists look at animals
 |
| 1. What is one theory about why the ammonites went extinct?
2. The ammonites were eaten by octopuses
3. People slowly killed off the ammonites
4. The ammonites had a hard time finding food

STOP. *Wait for your teacher to read the directions before answering the questions.***S-D.1.2. Mid-transfer passage: Archaeologists and the city of Pompeii**1Nearly 2,000 years ago, a volcano eruption destroyed an old city. It was called Pompei. The eruption of a mountain was brutal. It lasted for more than 24 hours. By the end, Pompeii was covered in ashes. Many people died. The city was totally destroyed. It was like a mass extinction.2But archaeologists discovered Pompeii again in 1748. They found fossilized humans—not dinosaur fossils but human fossils. A team of archaeologists found fossilized buildings and human and animal skeletons. 3Pompei is like a city frozen in time. But scientists are not studying the fossilized bones of dinosaurs. Instead, they are studying the buildings and other artifacts from Pompei. They also want to know what people were like.4One theory about Pompeii is that there were rich and poor people. Archaeologists have found fossilized big homes and small homes. 5Yes, Pompei was fossilized. So archaeologists have clues about life in Pompeii. Even the kinds of people who lived there.Questions

|  |
| --- |
| 1. According to the passage, who studies fossils of buildings destroyed by a volcano?
2. people in Pompeii
3. rich people
4. archaeologists
 |
| 1. This passage mainly tells about

how archaeologists study the old city of Pompeii what an archaeologist’s job is likehow a volcano destroyed a city called Pompeii |
|  |
| 1. In paragraph 4, theory can also be called:
2. An idea
3. A solution
4. An answer
 |
| 1. Archaeologists have studied the fossilized buildings and skeletons of Pompeii. Fossilized means:
2. Saved as it was years ago
3. New thing to help scientists
4. Physical characteristics
 |
| 1. How can we imagine what Pompeii was like a long time ago?
2. By studying many different books about the city
3. By studying the people currently living in Pompeii
4. By studying fossilized buildings and skeletons
 |
| 1. Which type of fossil would help an archaeologist learn about the past?
	1. Fossilized homes from a city
	2. Fossilized rocks from a volcano
	3. Fossilized bones from a dinosaur
2. How are the jobs of paleontologists and archaeologists the same?
	1. They both look for living animals
	2. They both dig for animal fossils
	3. They both use evidence to solve mysteries

**S-D.1.3. Far Transfer Passage: Genealogists and our descendants**1 Some people want to know more about their ancestors. They want to know about their relatives who lived a long time ago. Often there are no living family members who know about those relatives. So sometimes they hire a genealogist. 2A genealogist finds clues that help you to learn about your ancestors. You can learn about where your ancestors came from. You can learn about your ancestors' jobs. You can learn about what they looked like. Sometimes you can learn stories about them. 3Some people want to prove that an ancestor was in an important event like a war. Some people want to know if they are a descendant of a famous person. 4Other people just want to know their family lineage. Knowing about their ancestors can help them to understand themselves better. 5Sometimes the genealogist finds clues using the computer. Sometimes she uses a library. She might talk to individuals in other countries. She might travel to other places to get clues.Questions

|  |
| --- |
| 1. According to the passage, who uses clues to find out about ancestors?
	1. detectives
	2. famous people
	3. genealogists
 |
| 1. What is this passage mainly about?
2. Where ancestors come from
3. Why genealogists use the computer
4. What genealogists do
5. What do genealogists have to do first?
	1. Talk to people
	2. Find clues
	3. Travel to other places
6. In paragraph 3, descendant can also be called:
	1. An important war hero
	2. Someone who is born later
	3. A famous person who is alive today
 |
| 1. Why does the author think genealogists are important?
2. They are able to help famous people plan their jobs
3. They talk to people in other countries and cities
4. They help people find relatives from a long time ago
5. What is one reason people want to find ancestors?
6. To become famous like their ancestors
7. To prove their relative was an important person
8. To use the computer to find out facts
9. What is similar about the work that paleontologists, archaeologists, and genealogists do?
	1. They learn about things from the past
	2. They learn about ancestors’ jobs
	3. They learn about living things
 |
|  |

 |

 |

**S-D.2. Item Response Theory Analysis Results**

**S-D.2.1. Results based on Classical Test Theory Approach**

|  |  |  |  |
| --- | --- | --- | --- |
| **Item** | **Prop. Correct** | **Omitted-item alpha** | **Item-rest Correlation** |
| Near 1 | .82 | .77 | .33 |
| Near 2 | .32 | .78 | .17 |
| Near 3 | .50 | .78 | .26 |
| Near 4 | .37 | .78 | .28 |
| Near 5 | .29 | .78 | .22 |
| Near 6 | .62 | .78 | .23 |
| Near 7 | .60 | .77 | .38 |
| Mid 1 | .65 | .76 | .53 |
| Mid 2 | .52 | .77 | .30 |
| Mid 3 | .48 | .77 | .31 |
| Mid 4 | .53 | .78 | .25 |
| Mid 5 | .46 | .77 | .32 |
| Mid 6 | .47 | .77 | .38 |
| Mid 7 | .44 | .77 | .33 |
| Far 1 | .71 | .77 | .56 |
| Far 2 | .59 | .76 | .46 |
| Far 3 | .59 | .77 | .29 |
| Far 5 | .59 | .76 | .46 |
| Far 6 | .53 | .77 | .37 |
| Far 7 | .65 | .76 | .44 |

*Note*. The far-transfer passage item 4 was excluded due to a negative discrimination parameter.

**S-D.2.2. Results based on Item Response Theory Approach**

|  |  |  |
| --- | --- | --- |
| **Item** | **Difficulty** | **Discrimination** |
| Near 1 | -1.71 | 1.08 |
| Near 2 | 1.68 | 0.47 |
| Near 3 | -0.02 | 0.60 |
| Near 4 | 0.82 | 0.70 |
| Near 5 | 1.68 | 0.57 |
| Near 6 | -0.93 | 0.56 |
| Near 7 | -0.51 | 0.99 |
| Mid 1 | -0.52 | 2.08 |
| Mid 2 | -0.12 | 0.77 |
| Mid 3 | 0.10 | 0.80 |
| Mid 4 | -0.22 | 0.62 |
| Mid 5 | 0.23 | 0.83 |
| Mid 6 | 0.12 | 1.03 |
| Mid 7 | 0.30 | 0.92 |
| Far 1 | -0.70 | 2.46 |
| Far 2 | -0.34 | 1.55 |
| Far 3 | -0.52 | 0.80 |
| Far 5 | -0.34 | 1.55 |
| Far 6 | -0.13 | 1.09 |
| Far 7 | -0.61 | 1.47 |



**S-D.2.3. Results from Exploratory Factor Analysis**

Factor 1

Eigenvalue 3.29

Proportion 103.16%



**Supplementary Materials S-E**

*S-E.1. Grade 2 Science Vocabulary Knowledge Depth Assessment*

Practice Question 1: Circle two words that go with the word student.

Practice Question 2: Circle two words that go with the word afraid.

fear

blink

dinner

scare

|  |  |  |  |
| --- | --- | --- | --- |
| book | fox | classroom | boat |

1. Circle two words that go with carnivore.

|  |  |  |  |
| --- | --- | --- | --- |
| fruit | care | meat | prey |

1. Circle two words that go with extinct.

|  |  |  |  |
| --- | --- | --- | --- |
| gone forever | living | existing | lost |

1. Circle two words that go with fossil.

|  |  |  |  |
| --- | --- | --- | --- |
| utensil | bone | folks | footprint |

1. Circle two words that go with hypothesis.

|  |  |  |  |
| --- | --- | --- | --- |
| thought | poem | guess | hippo |

1. Circle two words that go with brutal.

|  |  |  |  |
| --- | --- | --- | --- |
| harsh | brave | cruel | friendly |
|  |  |  |  |

1. Circle two words that go with evidence.

|  |  |  |  |
| --- | --- | --- | --- |
| choosing | proving | showing | feeling |

1. Circle two words that go with theory.

|  |  |  |  |
| --- | --- | --- | --- |
| fairy | theme | argument | idea |

1. Circle two words that go with hunter.

|  |  |  |  |
| --- | --- | --- | --- |
| handout | catcher | search | conclusion |

1. Circle two words that go with organism.

|  |  |  |  |
| --- | --- | --- | --- |
| creature | animal | order | practice |

1. Circle two words that go with trait.

|  |  |  |  |
| --- | --- | --- | --- |
| characteristic | truth | exam | feature |

1. Circle two words that go with paleontologist.

|  |  |  |  |
| --- | --- | --- | --- |
| paint | history | dinosaur | pair |

1. Circle two words that go with reptile.

|  |  |  |  |
| --- | --- | --- | --- |
| mobile | lizard | report | cold-blooded |

Table S-E.2.

*Vocabulary Knowledge Depth Measure Scoring System*

|  |  |
| --- | --- |
| Score  | Item selection and correct/incorrect case  |
| 4  | Student circled two correct answers  |
| 3  | Student selected three items: two correct answers and one incorrect answer. Or, student selected one item: one correct answer.  |
| 2  | Student selected two items: one correct and one incorrect answer. Or, student selected four items: two correct and two incorrect answers.     |
| 1  | Student selected one item that was an incorrect answer. Or, student selected three items: one correct and two incorrect answers.   |
| 0  | Student selected two items that were incorrect answers.  |

*Note*. We used item-response-theory to fit graded response models that account for the multiple response options. These analyses replicated the results reported in the original study (Kim, Burkhauser, 2021). We used the 0-4 point scale in the paper because it allows us to report treatment-control differences in meaningful units (i.e., number of words learned).

**Supplementary Materials S-F**

*Multilevel Model to Examine Moderating Effects of Initial Domain-General Reading Comprehension*

We examined whether students’ initial domain-general reading comprehension scores (measured by MAP) moderated the impact of the treatment effect on Grade 2 students’ posttest outcomes (i.e., science content reading comprehension and vocabulary knowledge depth). The multilevel model was specified as follows:

*Yij* = γ00 + γ01*MOREj* + γ10*PRETESTi* + γ11*MOREj*$×$*PRETESTi* + $\sum\_{p=2}^{12}γ\_{p0}COV\_{i}$ + $\sum\_{q=2}^{8}γ\_{0q}$*BLOCKjq* + *εij* + $ζ\_{0j}$

*εij* ~ N(0, $σ^{2}$), $ζ\_{0j}$ ~ N(0, $τ\_{00}$).

In this model, *Yij* is the posttest score of student *i* in school *j.* The parameters γ00, γ01, γ10, and γ11 represent the intercept, the main treatment effect, the MAP pretest reading score effect, and the cross-level interaction effect between treatment and the MAP pretest reading scores, respectively. The parameters γ*p*0 and γ0*q* represent the effects of demographic characteristics covariates (*p* = 2, …, 12) and randomization blocks (*q* = 2, …, 8), respectively. The model included the level-1 and -2 residuals, *εij* and $ζ\_{0j}$,respectively, assumed to be normally distributed with a mean of zero and uncorrelated with covariates. The results in Table S-F revealed that the interaction effects between treatment and pretest reading scores on domain-specific reading comprehension and vocabulary knowledge depth outcomes were weak but statistically significant for Near Transfer and Taught Vocabulary.

Table S-F. *Results of Treatment-by-Pretest Interaction Treatment Effects on Grade 2 Students’ (*N *= 2,156) Science Content Reading Comprehension and Science Vocabulary Knowledge Depth*

|  |  |
| --- | --- |
|  | Coefficient (SE) |
|  | Science content reading comprehension | Science vocabulary knowledge depth |
| Source | Overall | Near transfer | Mid transfer | Far transfer | Overall | Taught | Untaught |
| Fixed effects |  |  |  |  |  |  |  |
| Intercept, γ00  | .19 (.16) | .12 (.17) | .03 (.17) | .29 (.17)† | -.08 (.16) | -.19 (.17) | .08 (.17) |
| Treatment, γ01 | .18 (.06)\*\*  | .22 (.06)\*\*\*  | .17 (.06)\*\*  | .04 (.06)  | .04 (.06)  | -.01 (.06)  | .11 (.06)†  |
| Pretesta, γ10 | .43 (.04)\*\*\* | .33 (.05)\*\*\* | .33 (.04)\*\*\* | .36 (.04)\*\*\* | .39 (.04)\*\*\* | .34 (.04)\*\*\* | .39 (.04)\*\*\* |
| Treatment x Pretesta, γ11 | .01 (.04) | .09 (.04)\* | .003 (.04) | .01 (.04) | .07 (.04)† | .09 (.04)\* | .03 (.04) |
| Variance components |  |  |  |  |  |  |  |
| Level 1, *εij*  | .59 | .78 | .69 | .72 | .656 | .69 | .71 |
| Level 2, $ζ\_{0j}$ | .02 | .02 | .02 | .02 | .021 | .02 | .02 |

*Note*. Student demographic characteristics (i.e., gender, race/ethnicity, grade, limited English proficiency/individual education plan status, socioeconomic status), Measures of Academic Progress (MAP) mathematics pretest scores and school randomization blocks were included in the analyses as covariates but suppressed in Table.

aMAP reading pretest (baseline).

†*p* < .10, \**p* < .05, \*\**p* < .01, \*\*\**p* < .001

**Supplementary Materials S-G**

*Multiple Imputation for Missing Data in Assessing Treatment Effects on Science Content Reading Comprehension and Vocabulary Knowledge Depth*

Missing values existed for the Measures of Academic Progress (MAP) baseline MAP mathematics (0.8%) pretest scores. With the assumption that data were missing at random (MAR), in which the probability of missing values was systematically related to the observed but not the unobserved data, we used multiple imputation by simulating 10 data sets with plausible values in place of missing observations as a sensitivity check for the main effect models (research question 2). The procedure was performed using a Markov Chain Monte Carlo (MCMC) algorithm with a multivariate normal distribution using the *mi impute mvn* command in Stata. We did not impute posttest scores.

Results from the multiple imputation analysis of the main treatment effects (see Table S-G) revealed no substantive changes in the interpretation. Furthermore, results were robust to the alternative pretest specification in interaction models, which used only the linear term of baseline MAP reading scores rather than cubic forms of both reading and mathematics MAP scores.

Table S-G. *Sensitivity Analysis Results of Main Treatment Effects on Science Content Reading Comprehension and Science Vocabulary Knowledge Depth Using Multiple Imputation for Missing Data (*N *= 2,174)*

|  |  |
| --- | --- |
|  | Coefficient (SE) |
|  | Science content reading comprehension | Science vocabulary knowledge depth |
| Source | Overall | Near transfer | Mid transfer | Far transfer | Overall | Taught | Untaught |
| Fixed effects |  |  |  |  |  |  |  |
| Intercept  | .09 (.16) | -.01 (.17) | -.03 (.17) | .24 (.17) | -.15 (.16) | -.23 (.17) | -.02 (.17) |
| Treatment | .17 (.06)\*\* | .23 (.06)\*\*\* | .16 (.06)\*\* | .04 (.06) | .05 (.06) | -.01 (.06) | .12 (.06)† |
| Variance components |  |  |  |  |  |  |  |
| Level 1  | .57 | .76 | .68 | .72 | .64 | .68 | .69 |
| Level 2 | .02 | .02 | .02 | .02 | .02 | .02 | .02 |

*Note*. Student demographic characteristics (i.e., gender, race/ethnicity, grade, limited English proficiency/individual education plan status, socioeconomic status), Measures of Academic Progress (MAP) reading and mathematics pretest scores, and school randomization blocks were included in the analyses as covariates but suppressed in Table.

†*p* < .01, \**p* < .05, \*\**p* <.01, \*\*\**p* < .001.