

## *ANALYSIS: Making Learning Count*

### General Notes:

1. This documents outline our main tests regarding causal effects of the treatment. We will also do complementary analysis to both describe and examine the channels/mechanisms through which children learn.
2. Practice trials are never included in any of these analyses.
3. Responses of “I don’t know”, “refuse to answer” or trials skipped due to actions of the child (such as crying) are coded as incorrect; trials are not scored if the child does not finish the test for reasons beyond their control (such as a computer failure).
4. Percentage of correct responses is calculated by dividing the number of correct trials by the number of trials given (i.e., correct/(correct + incorrect + I don't know + refuse to answer)). Trials that are not given due to circumstances beyond the child’s control do not enter into this calculation.
5. Z-scores are calculated by standardizing to the baseline control values.
6. Throughout we use the following regression frameworks:

$$y_{i,j} = \text{math}_j + \text{social}_j + \text{age}_{i,j} + \text{gender}_{i,j} + \varepsilon_{i,j} \quad (1)$$

$$y_{i,j} = \text{math}_j + \text{social}_j + \text{age}_{i,j} + \text{gender}_{i,j} + \text{baseline}_{i,j} + \varepsilon_{i,j} \quad (2)$$

Where  $y_{i,j}$  represents the endline value of an outcome for child  $i$  in school  $j$ ,  $\text{math}_j$  is a indicator variable for whether school  $j$  was treated with the math games intervention,  $\text{social}_j$  is an indicator variable for whether school  $j$  was treated with the social games intervention,  $\text{age}_{i,j}$  is age in months of child  $i$  in school  $j$ ,  $\text{gender}_{i,j}$  is gender of child  $i$  in school  $j$ , and  $\text{baseline}_{i,j}$  is the baseline value of outcome  $y_{i,j}$  for child  $i$  in school  $j$ . Standard errors will be clustered at the school level.

### Overall Outcomes and Hypotheses:

- Main Outcome: Z-Score of percentage correct across all math tests (Geometric Intruder, Panamath, Point to a Number, Point to a Shape and Extra Math Measures)
- Hypothesis:
  - The math treatment will generate positive effects and the social treatment will generate smaller effects.
  - Due to varying similarity of the tests to the math intervention, treatment effects will be observed in the following descending order of likelihood:
    - Closest to intervention: Geometric Intruder
    - Next closest: Point to a Shape
    - Furthest: Extra Math Measures, Point to a Number and Panamath
- Test: Regress outcomes using (1) and (2)

### Test Specific Outcomes and Hypotheses:

Geometric Intruder: There are 3 practice trials and 6 test trials.

- Main outcome: Percentage of correct responses
- Hypothesis: This is the most direct test of the math treatment. The math intervention will generate positive effects and the social intervention will generate no effects.
- Test: Regress outcomes using (1) and (2)

Panamath: There are 2 practice trials and 40 test trials. Practice trials may be repeated either before each block (if children get them wrong) or in the middle of a block (if children persevere on one response side).

- Main outcome: Percentage of correct responses
- Hypothesis: The math intervention will generate positive effects and the social intervention will generate smaller effects.
- Test: Regress outcomes using (1) and (2)

Point to a Number: There is 1 practice trial and 5 test trials.

- Main outcome: Percentage of correct responses
- Hypothesis: The math intervention will generate positive effects and the social intervention will generate smaller effects.
- Test: Regress outcomes using (1) and (2)

Point to a Shape: There is 1 practice trial and 5 test trials.

- Main outcome: Percentage of correct responses
- Hypothesis: The math intervention will generate positive effects and the social intervention will generate smaller effects.
- Test: Regress outcomes using (1) and (2)

Extra Math Measures: There are 10 test trials.

- Main outcome: Percentage of correct responses counting either a verbal or non-verbal correct response as correct
- Other outcomes of interest:
  - Percentage of correct responses counting only correct verbal responses as correct
- Hypothesis: The math intervention will generate positive effects and the social intervention will generate smaller effects.
- Test: Regress outcomes using (1). Regress outcomes using (2), but because baseline values are not available for this test, instead of  $baseline_{i,j}$  include an average of the Z-scores of the percentage correct on all other Math games at baseline to control for baseline ability.

Motivation Questions: There are 4 practice questions followed by 11 test questions. Questions 5 and 8 are filler questions, so that the appropriate wording is chosen for the other questions. They should not be included in the analysis and are thus not included in the description of outcomes below.

- Outcomes:
  - Overall Enjoyment of School: Q11
  - Math Motivation-Average of Z-Scores of:

- *Fluid/Fixed Math*: Q1 (binary 1 or 2 with 1 indicating fluid, 2 indicating fixed) and Q2 (4-point scale with higher numbers indicating more fixed)
    - *Liking Math*: Q6 (4-point scale with higher numbers indicating greater enjoyment)
    - *Good at Math*: Q7 (4-point scale with higher numbers indicating a better self-assessment of math ability)
  - Reading Motivation-Average of Z-Scores of:
    - *Fluid/Fixed Reading*: Q3 (binary 1 or 2 with 1 indicating fluid, 2 indicating fixed) and Q4 (4-point scale with higher numbers indicating more fixed)
    - *Liking Reading*: Q9 (4-point scale with higher numbers indicating greater enjoyment)
    - *Good at Reading*: Q10 (4-point scale with higher numbers indicating a better self-assessment of reading ability)
  - Overall Motivation- Average of the reading motivation and math motivation measures described above
- Hypotheses:
  - Children trained on any engaging content in a school setting (students in schools treated with either the math or social intervention) will like school better overall generating positive effects on Q11.
  - The math intervention will increase enjoyment of math, and sense of efficacy at math, generating positive effects on Q6 and Q7.
  - The math intervention will increase the perception of math knowledge as fluid generating positive effects on Q1 and Q2.
  - The reading questions are “control questions” and the math intervention should increase them less (though they may still increase).
  - The social intervention may increase the scores of all questions, but not differentially for math and reading.
- Test: Regress using (1) and (2).
- Ancillary analysis: Examining results of each question.

#### Robustness Checks:

Executive Function: 4 Blocks with 4 practice trials and 20 test trials. Practice trials may be repeated either before each block (if children get more than half wrong) or in the middle of a block (if children persevere on one response side). Anticipatory responses (those faster than 200 ms) are removed from the analysis.

- Main outcome: Difference between the percentage of correct answers between blocks 1 and 2 (response switching) and difference between the percentage of correct answers between block groups 3-4 and 1-2 (task switching)
- Other outcomes of interest:
  - Difference between the median response time to correct answers between blocks 1 and 2 (response switching) and difference between the median response time to correct answers between block groups 3-4 and 1-2 (task switching)
  - Percentage of correct responses on each block
  - The average across blocks of Z-scores of the percentage of correct answers.

- Negative of the median response time to correct answers across all four blocks (so that higher is better)
- Average of Z-scores of the negative of median response time to correct answers and the percentage of correct responses across all blocks (so that a higher Z-score is better)
- Hypothesis: No interventions will generate effects on these measures.
- Test: Regress outcomes using (1) and (2)

Gaze Intruder: There are 3 practice trials and 6 test trials.

- Main outcome: Percentage of correct responses
- Hypothesis: This is the most direct test of the social treatment. The social intervention will generate positive effects and the math intervention will generate smaller effects
- Test: Regress outcomes using (1) and (2)