A Study of the Impact of an Early Childhood Intervention on STEM Learning

The University of Toledo
Charlene Czerniak, Joan Kaderavek, Peter Paprzycki, Scott Molitor, Susanna Hapgood, Jeanna Heuring, and Grant Wilson

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Theory of Action

Early Childhood Science Teacher Professional Development

Teacher science content knowledge

Teacher pedagogy

Classroom Practice

Student Achievement

Family Engagement in Science

Improves

Changes

Implements an additive impact on
NURTURES Program

NURTURES Phase I: 2011-2017
• Notable research findings:
  • Improved student achievement in math, early literacy, reading
  • Longitudinal effects in math, reading, and science

NURTURES Phase II: 2017-2020
• Research Aims:
  • Student achievement across three samples groups: Control, PD & PD + Family Engagement

Phase I: NSF #1102808 | Phase II: NSF #1721059
Study Focus

• Investigate whether exposure to NURTURES-trained teachers affected student learning outcomes for PreK-K in science, mathematics, early literacy, and reading.

• Determine if children whose families participated in family engagement STEM provided an additive positive impact on child outcomes.
Family Engagement in STEM Learning During Early Childhood

Need for family engagement:
- Children spend less than 20% of their day in school
- Families focus on reading and math vs. science and engineering
- Parental factors – low interest, anxiety, and confidence

Strategies for family science engagement:
- Community-based – informal science learning venues
- School-based – family engagement kits
- Home-based – family engagement packs
State of EC STEM Assessment

STEM assessment of very young children poses challenges:

- Aligned with curriculum
- Authentic tasks or observation of abilities - in real time
- Developmentally appropriate-not paper and pencil
- Easily incorporated into ongoing evaluation procedures

Current science assessment tools:

- Science Learning Assessment (SLA-Purdue)
- Woodcock-Johnson-III Science Knowledge Subscale (WJ-III-HMHCO)
- Preschool Science Assessment (PSA-U Miami)
- Early Learning Scale (ELS/KELS-NIEER)
Methods

Program

Professional Development
  • Summer Institute & AY PLCs

Family Engagement Resources *(randomized group)*
  • Family Packs
  • Family Engagement Events

Early Learning Scale Instrument
  • Rubric scoring on select items focused on math, science, language & literacy
  • Teachers collected Fall & Spring data

Early Learning Scale Training
  • Web-based training on scope and application
  • Aim to Integrate with existing assessment protocols
Study Participants

Selection:

- RCT research design
- PreK-K programs from sixteen rural Midwestern schools
- Participants active in program for 1 year
- Male/Female students evenly distributed
Instrument

Domain: Math/Science
Item 1: Number and Numerical Operations
Item 2: Classification and Algebraic Thinking
Item 3: Geometry and Measurement
Item 4: Scientific Inquiry

Domain: Language and Literacy
Item 7: Oral Language
Item 8: Phonological Awareness
Item 9: Print Awareness
Item 10: Writing
Instrument Scoring
Examination and Reconsideration of Prescribed Scoring Procedures

For further information on the ELS/KELS instrument visit:
www.myelsonline.com
## Instrumentation: PreK

<table>
<thead>
<tr>
<th>Items</th>
<th>Number of Items</th>
<th>Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domain: Math/Science</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 1: Numbers and numerical operations</td>
<td>3</td>
<td>01 = Num.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>02 = Num.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>03 = Num.3</td>
</tr>
<tr>
<td>Item 2: Classification and algebraic thinking</td>
<td>2</td>
<td>04 = Class.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>05 = Class.2</td>
</tr>
<tr>
<td>Item 3: Geometry and measurement</td>
<td>2</td>
<td>06 = Geom.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>07 = Geom.2</td>
</tr>
<tr>
<td>Item 4: Scientific inquiry</td>
<td>3</td>
<td>08 = SI.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>09 = SI.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 = SI.3</td>
</tr>
<tr>
<td><strong>Domain: Language and Literacy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 7: Oral language</td>
<td>2</td>
<td>11 = OLAN.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 = OLAN.2</td>
</tr>
<tr>
<td>Item 8: Phonological awareness</td>
<td>1</td>
<td>13 = Phon</td>
</tr>
<tr>
<td>Item 9: Print awareness</td>
<td>2</td>
<td>14 = Read.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 = Read.2</td>
</tr>
<tr>
<td>Item 10: Writing</td>
<td>2</td>
<td>16 = Write.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 = Write.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
Measurement Model: PreK and K

Recommended scoring model did not work well.

- Used Polytomous Rasch Rating Scale Model (RSM) (Andrich, 1978a, 1978b) as implemented in Winsteps (Linacre 2009) software to evaluate all items

- Rating Scale utilized three observable scores for all items:
  - “1” (observed) = “1” (recoded)
  - “3” (observed) = “2” (recoded)
  - “5” (observed) = “3” (recoded)

- Fall 2018 anchored items measures were used to calibrate Spring 2019 items measures (Fall 2018 frame-of-reference)

- Obtained scale-free calibrations of all items (not just strands) difficulty levels and children’s ability measures
## Demographics: PreK

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Fall 2018</th>
<th>Spring 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Intervention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>136</td>
<td>40</td>
</tr>
<tr>
<td>PD</td>
<td>83</td>
<td>24</td>
</tr>
<tr>
<td>PD+</td>
<td>120</td>
<td>35</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>161</td>
<td>47</td>
</tr>
<tr>
<td>Male</td>
<td>175</td>
<td>52</td>
</tr>
<tr>
<td>Missing</td>
<td>3</td>
<td>1</td>
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### Linear Regression Results: PreK

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $B_0$</td>
<td>2.73</td>
<td>0.25</td>
<td>11.12</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Fall measure, $B_1$</td>
<td>0.94</td>
<td>0.05</td>
<td>20.66</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Gender, $B_2$</td>
<td>0.02</td>
<td>0.23</td>
<td>0.07</td>
<td>.941</td>
</tr>
<tr>
<td>Intervention, $B_3_{(PD)}$</td>
<td>0.96</td>
<td>0.30</td>
<td>3.22</td>
<td>.001</td>
</tr>
<tr>
<td>Intervention, $B_4_{(PD+)}$</td>
<td>0.79</td>
<td>0.27</td>
<td>2.92</td>
<td>.004</td>
</tr>
</tbody>
</table>

**Regression approach was used:**
- Spring 2019 – outcome variable
- Fall 2018 – covariate
- Gender – factor (controlling variable)
- Intervention - factor
Results Marginal Effects: PreK

Fall.Measure effect plot

Gender effect plot

Intervention effect plot
## Demographics: K

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Intervention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>46</td>
<td>49</td>
</tr>
<tr>
<td>PD</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>PD+</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>46</td>
<td>49</td>
</tr>
<tr>
<td>Male</td>
<td>48</td>
<td>51</td>
</tr>
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### Domain: Math/Science

- **Item 1: numbers and numerical operations**
  - 3 items
  - 01 = Num.1
  - 02 = Num.2
  - 03 = Num.3

- **Item 2: classification and algebraic thinking**
  - 2 items
  - 04 = Class.1
  - 05 = Class.2

- **Item 3: geometry and measurement**
  - 2 items
  - 06 = Geom.1
  - 07 = Geom.2

- **Item 4: scientific inquiry**
  - 3 items
  - 08 = Sl.1
  - 09 = Sl.2
  - 10 = Sl.3

### Domain: Language and Literacy

- **Item 7: oral language**
  - 2 items
  - 11 = OLAN.1
  - 12 = OLAN.2

- **Item 8: phonological awareness**
  - 1 item
  - 13 = Phon

- **Item 9: reading**
  - 3 items
  - 14 = Read.1
  - 15 = Read.2
  - 16 = Read.2

- **Item 10: writing**
  - 2 items
  - 17 = Write.1
  - 18 = Write.2

**Total**

- 18 items
# Linear Regression Results: K

Regression approach was used:
- Spring 2019 – outcome variable
- Fall 2018 – covariate
- Gender – factor (controlling variable)
- Intervention - factor

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<tr>
<td>Intercept, B₀</td>
<td>3.74</td>
<td>0.66</td>
<td>5.69</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Fall measure, B₁</td>
<td>0.51</td>
<td>0.14</td>
<td>3.66</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Gender, B₂</td>
<td>-0.10</td>
<td>0.71</td>
<td>-0.14</td>
<td>.887</td>
</tr>
<tr>
<td>Intervention, B₃ (PD)</td>
<td>0.98</td>
<td>0.86</td>
<td>1.14</td>
<td>.258</td>
</tr>
<tr>
<td>Intervention, B₄ (PD+)</td>
<td>2.46</td>
<td>0.98</td>
<td>2.52</td>
<td>.014</td>
</tr>
</tbody>
</table>
Results Marginal Effects: K

MEASURE.Fall effect plot

Gender effect plot

Intervention effect plot
Conclusions & Implications

✓ NURTURES programming shows a positive impact on PreK-K student achievement.

✓ Preliminary findings indicate the usefulness of the ELS/KELS instrument for EC STEM assessment.

Further research will involve gathering data on student achievement, fidelity of implementation with family engagement components, and inter-rater reliability.
Questions & Contact Info

For further information on NURTURES visit:

nurtures.utoledo.edu

or email: nurtures@utoledo.edu

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