Fostering Young Children’s Spatial Thinking

An important but often neglected aspect of early mathematics

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Importance of Early Mathematics

• Children who enter kindergarten behind in math tend to stay behind (Duncan et al., 2007)

• Math levels at kindergarten entry predict reading as well as math achievement through at least 5th grade (Duncan et al., 2007)

• Strong math skills provide the foundation for success in the STEM disciplines
Most Important Aspects of Early Math

• Number and Operations
• Geometry and Spatial Relations

NRC REPORT, 2009: Mathematics Learning in Early Childhood: Pathways to Excellence and Equity
Spatial Thinking Is Important to Performance in STEM Disciplines

Geoscience
Engineering
Physics
Chemistry
Biology
Mathematics
Mean Spatial Scores by Occupation
(adapted from Wai, Lubinski, & Benbow, 2009)
Spatial Learning in the Early Years

• Largely limited to identifying shapes
• Can be much more ambitious
  – Young children can acquire spatial visualization skills that are important in STEM
    – By engaging in spatial activities
    – By hearing and acquiring spatial language
Longitudinal Language Study Database for our studies

• Diverse sample of parent-child dyads followed longitudinally.
  – 30 boys; 28 girls
• Dyads observed at home for 90 minutes every four months starting at 14 months of age.
Study 1: Puzzle Play

• All episodes of puzzle play between 26 and 46 months were identified and coded
• Question: Is early puzzle play associated with later spatial visualization, as assessed by a mental rotation test?
Parent-Child Puzzle Interaction

Video will be shown
Mental Transformation Task
(Levine, Huttenlocher, Taylor & Langrock, 1999)

• Administered when children were 54 months old

• Assesses children’s ability to mentally transform shapes.

• Child asked to select the shape the pieces make.
Children who played with puzzles scored higher on the mental rotation task.

Levine, Ratliff, Cannon, & Huttenlocher, under review
Study 2: Relation Between Spatial Language and Spatial Thinking

• Question: Does parent spatial language use predict children’s later spatial skill?

• Coded all parent and child uses of:
  – Shape terms (e.g., square, circle)
  – Dimensional adjectives (e.g., tall, short, wide, narrow)
  – Spatial features (e.g., curved, straight, corner, edge)
Spatial Language Use Shows Large Individual Variations

- On average, children produced 74 spatial words (SD= 46; **Range 4-191**) spatial words across 9 sessions (13.5 hours).

- On average, parents produced 167 spatial words (SD= 121; **Range 5-525**) spatial words across 9 sessions (13.5 hours).

(Pruden & Levine, In Press)
Parents’ Use of Spatial Language Can Make a Difference

Parent Spatial Tokens $\rightarrow$ Child Mental Transformation Scores $\beta = .53^*$

Child Spatial Tokens $\rightarrow$ Parent Spatial Tokens $\beta = .91^{***}$
Child Spatial Tokens $\rightarrow$ Child Mental Transformation Scores $\beta = .42^*$

Parent Spatial Tokens $\rightarrow$ Child Mental Transformation Scores $\beta = .15$

$N = 52; \; ^* p \leq 0.05; \; ^{**} p \leq 0.01; \; ^{***} p \leq 0.001$
Summary: Study 2 Findings

- Parents’ use of spatial language predicts children’s use of spatial language,
- Children’s use of spatial language in turn predicts their spatial visualization skills.
An Additional Finding

• When parents spatial language is accompanied by gesture, this is particularly predictive of children’s use of spatial language (Cartmill, Pruden, Levine, & Goldin-Meadow, 2009)

“It’s a circle”
Implications: Two Ways Parents Can Foster Children’s Spatial Learning

• Engage children in puzzle play
• Talk to children about spatial relationships—sizes, shapes, and spatial features and use gestures with this talk
Early Spatial Learning

• Helps prepare children for success in math and science
"You have to solve this problem by yourself. You can't call tech support."
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