It's a Pattern! The Importance of Early Pattern Knowledge for Middle Grade Mathematics Achievement

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ABSTRACT

Educators and policy makers debate whether the prevalence of patterning in early mathematics education is appropriate. Children (n = 517) from low-income homes completed a variety of assessments at ages 7 and 11, including a patterning assessment. Pattern knowledge at age 7 predicted math achievement in Numeration, Algebra and Geometry at age 11, over and above general reading, math and oral language skills. Patterning knowledge is predictive of later math achievement.

Background

Patterns are a predictable sequence, ranging from alterations of colors to complex mathematical relations.

Young children, parents and teachers emphasize patterns in the world (Rittle-Johnson et al., in press), and some consider patterns a central idea in mathematics (Charles, 2005; Sarama & Clements, 2004).

Struggling first-grade students who received pattern instruction had greater mathematics knowledge at year's end than students in a variety of control groups (Kidd et al., 2013; 2014).

However, the National Mathematics Advisory Panel (2008) concluded that "patterns are not a topic of major importance" (p. 59).

Current Study

The current study explored whether pattern knowledge at age 7 was predictive of mathematics achievement in the middle grades.

Method

***Participants*:**

- 517 students from low-income homes, originally recruited from pre-kindergarten classroom and participating in the Peabody Research Institute Middle School Follow Up Project (56% female; 79% Black, 9% Caucasian).
- Focus on data collected at Age 7 (M = 7.0, *SD* = 0.32) and Age 11 (M = 11.0, SD = 0.32) when 86% were near end of 5th grade and 14% had been retained (in 4th grade)

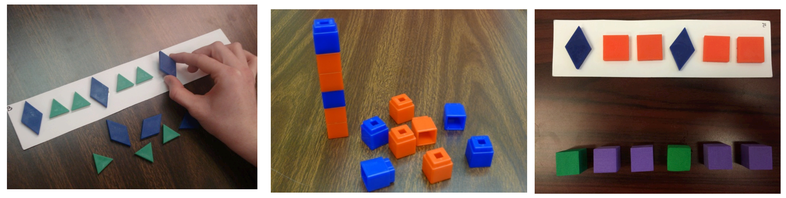
Age 7 Predictor Measures:

- Four subtests from the Woodcock Johnson III Tests of Achievement: *Quantitative Concepts* (math), *Applied Problem Solving* (math), *Letter-Word Identification* (reading) and *Story Recall* (oral language).
- Research-based Early Maths Assessment (REMA; Clements, Sarama & Liu, 2008). Focused on the 7 *pattern* items, with sample items in Figure 1.
- Teacher ratings of *attentive behavior* (Cooper-Farran work-related skills) and *self-regulation* (from Instrumental Competence Scale for Young Children-Short Form)

Age 11 Mathematics Achievement Measures:

- Three KeyMath 3 Diagnostic Assessment subtests - Numeration, Algebra and Geometry (individually administered)
- WJ III Quantitative Concept subtest
- Composite math achievement measure: sum of z-scores on KeyMath and Quantitative Concept subtests
- State test score in mathematics

Sample Pattern Items



Extend ABB pattern ***Smallest Tower (AAB)*** ***Abstract ABB pattern***

From Clements, Sarama and Liu (2008)

Results

Average age-equivalent scores on the KeyMath indicated that children were about 2 years behind in mathematics (Numeration = 9.2 years; Algebra = 9.2 years; Geometry = 8.6 years).

All Age 7 academic skills were moderately correlated with Age 11 math outcomes and with each other (see Table 1).

Table 1: Correlations between Key Variables

Measure	1	2	3	4	5	6	7
1. KeyMath Numeration (age 11)	-						
2. KeyMath Algebra (age 11)	.83	-					
3. KeyMath Geometry (age 11)	.69	.66	-				
4. Quant. Concepts (age 11)	.67	.68	.53	-			
5. Pattern (age 7)	.39	.39	.39	.31	-		
6. Quant. Concepts (age 7)	.58	.57	.42	.52	.46	-	
7. Applied Problems (age 7)	.62	.58	.53	.53	.45	.60	-
8. Reading (age 7)	.47	.50	.39	.54	.29	.60	.53

Table 2: Regression Estimates for Age 7 Skills as Predictors of Age 11 Math Achievement

Measure	Composite Math Score	KeyMath Numeration	Key Math Algebra	KeyMath Geometry	Quantitative Concepts	State Test Score in Math
Academic Skills						
Pattern	.11 (.03)**	.08 (.04)*	.09 (.04)*	.17 (.04)***	.03 (.04)	.01 (.04)
Math: Quant. Concepts	.16 (.04)***	.22 (.04)***	.20 (.05)***	.02 (.05)	.10 (.05)*	.08 (.05)
Math: Applied Problems	.32 (.04)***	.33 (.04)***	.25 (.04)***	.32 (.05)***	.20 (.05)***	.17 (.05)**
Reading	.12 (.04)**	.05 (.04)	.09 (.05)	.11 (.05)*	.16 (.05)**	.19 (.05)**
Cognitive Skills						
Oral Language	.09 (.03)**	.05 (.03)	.05 (.04)	.11 (.04)**	.11 (.04)**	.05 (.04)
Attentive Behavior rating	.24 (.06)***	.16 (.06)**	.30 (.06)***	.19 (.07)**	.18 (.06)**	.23 (.08)**
Self-Regulation rating	-.02 (.06)	.02 (.06)	-.06 (.06)	-.10 (.07)	.08 (.06)	-.02 (.08)
Controls	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.

Note: Standard errors in parentheses. All variables were standardized and standardized regression coefficients are reported. Control variables included gender, ethnicity, SES composite with maternal education and level of income, ELL status, PreK school type, age at time of testing at both time points & grade level at Age 11, *p < .05. **p < .01. ***p < .001.

Conclusion

Skill with repeating patterns at age 7 (first grade) was a reliable predictor of age 11 mathematics knowledge and was not redundant with other measures of mathematics knowledge.

The pattern tasks required explicit attention to the underlying rule in the pattern, which is a core component of mathematics. Patterning is important in the early grades.

Patterns rely on spatial skills, which are important for mathematics achievement (Cheng & Mix, 2013), and may provide opportunities to practice spatial skills.

Results Cont.

Age 7 math and reading skills were strong predictors of most math outcomes (Table 2).

Age 7 pattern knowledge predicted all three KeyMath outcomes and composite math scores, over and above other predictors.

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