Home Patterning Activities and Young Children's Math Performance

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Introduction

Patterning skills are the ability to detect the regularities.

Importance of patterning skills in mathematics

- Patterning skills are related to mathematics achievement in both concurrent (e.g., Lee, Ng, Bull, Pe, & Ho, 2011; Lee et al.,2012; Warren & Miller, 2013) and longitudinal studies (e.g., Rittle-Johnson, Fyfe, Hofer, & Farran, 2017).
- Intervention studies also provided evidence relating patterning skills to mathematics performance (Kidd et al., 2013; Kidd et al., 2014; Papic, Mulligan, & Mitchelmore, 2011).

Home patterning activities and children's patterning skills

- The positive influence of home numeracy activities on children's early math performance is supported by evidence from intervention studies (e.g., Niklas, Cohrssen, & Tayler, 2016) and longitudinal studies (e.g., Anders et al., 2012).
- A few studies examined home patterning activities and the findings were mixed. In the study by Rittle-Johnson et al. (2015), the frequency of home patterning activities was found marginally related to children's patterning skills, despite of a small sample size. However, a parent-report study with larger sample failed to find a similar link (Zippert & Rittle-Johnson, 2020). In another study observing parent-child play time, no significant links were found between observed parent-child pattern activities and children's math and pattern skills (Zippert et al., 2020).
- Parents' belief about their child's patterning ability was positively related to patterning supports provided at home (Zippert & Rittle-Johnson, 2020).

Research Questions

- How frequently do kindergarten children and parents in Hong Kong engage in pattern-related activities at home?
- How does this frequency relate to children's patterning skills and math performance?
- What are the possible factors affecting this frequency?

Methods

- Parents of K2 children in four kindergarten in Hong Kong were invited to fill in a parent survey. 128 parents returned survey and their children were administered measures of patterning skills, general cognitive skills, language ability, and mathematics knowledge.

		Content / Sources
Parent Survey	• Home patterning activities • Math-related attitudes • Math-related expectations on their children	items selected and adapted from the parent and teacher survey used in Rittle-Johnson et al. (2015) and Skwarchuk, Sowinski and LeFevre (2014)
Child Measures	• Patterning skills	duplication, extension, abstraction and unit recognition of repeated patterns (Rittle-Johnson et al., 2013)
	• Mathematics knowledge	KeyMath Revised (Connolly, 2000)
	• Language ability	an expressive language screening tool designed for local kindergarteners (Lam, 2010)
	• General cognitive skills	part A of the Raven Progressive Matrices (Raven, 1958)

Approach for Data Analysis

- A series of principal component analyses (PCA) were administered with the scales in the parent survey.
- Factor scores created from survey data were used for correlational analysis.

Results

Home patterning activities survey items	M	SD	PCA loadings
Figure out what comes next in a pattern	2.84	1.34	.84
Say in words what the pattern is ("The apples are arranged in red, green, red, green.")	3.42	1.45	.80
Copy a pattern by making the same type of pattern, but with different materials	2.88	1.36	.79
Play hand or movement games that involve patterns	3.26	1.35	.78
Discuss patterns in days of the week, months of the year, or seasons	2.73	1.20	.70
Play board games with a pattern on the board	2.84	1.33	.66
Arrange objects in patterns (such as arranging blocks in colour patterns)	3.82	1.22	.57

Note. (i) Rated on a 6-point Likert-type scale, where 1 = never, 2 = once a month or less, 3 = 2- to 3-times a month, 4 = 1- to 2-times a week, 5 = 3- to 4-times a week, 6 = daily. (ii) The one-factor structure accounted for 54.4% of the variance in home patterning activities survey.

Parent attitudes survey items	M	SD	PCA loadings	
			1	2
Attitudes to Spatial and Patterning				
I am now good at spatial tasks (e.g., drawing 3D diagrams/reading map).	2.73	0.74	.870	
My job frequently involves spatial tasks.	2.48	0.78	.824	
I am now good at recognizing patterns.	2.87	0.70	.815	
My job frequently involves the use of patterns.	2.65	0.76	.800	
I was good at spatial tasks at school.	2.64	0.78	.685	
I was good at recognizing patterns at school.	2.89	0.68	.652	
Attitudes to Mathematics				
I was good at mathematics at school.	2.55	0.74		.928
I am now good at mathematics.	2.45	0.69		.844

Note. (i) Rated on a 4-point Likert-type scale, where 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree. (ii) The two-factor structure accounted for 72.9% of the variance in parent attitudes survey.

Parent expectations survey items	M	SD	PCA loadings	
			1	2
Basic Numeracy Expectations				
Arrange objects in order (e.g., arrange according to size)	4.52	0.65	.880	
Categorize objects (e.g., red in one group while blue in another group)	4.41	0.73	.874	
Identify shapes (e.g., triangle, square)	4.41	0.68	.860	
Understand spatial concepts (e.g., front, back, left, right, far, near)	4.41	0.69	.845	
Arrange objects in patterns (e.g., colour alternating when arranging blocks)	4.27	0.72	.763	
Advanced Numeracy Expectations				
Count to 1000	3.06	1.01		.897
Write numbers up to 100	3.96	0.94		.879

Note. (i) Rated on a 5-point Likert-type scale, where 1 = unimportant, 2 = quite unimportant, 3 = important, 4 = extremely important. (ii) The two-factor structure accounted for 75.4% of the variance in parent expectations survey.

	Partial correlations	1	2	3	4	5	6	7	8
1	Patterning skills	-							
2	Keymath - Addition	0.45***	-						
3	Keymath - Applications	0.38***	0.46***	-					
4	Home patterning activities	0.26*	0.21*	0.22*	-				
5	Attitudes to spatial and patterning	-0.04	-0.09	-0.10	0	-			
6	Attitudes to mathematics	0.13	0.04	0.10	0.23*	0.03	-		
7	Basic numeracy expectations	-0.04	-0.01	-0.03	0.41***	0.16	0	-	
8	Advanced numeracy expectations	-0.07	-0.05	-0.03	0.21*	0.04	0.17	0	-

Note. *p < 0.05 **p < 0.01 ***p < 0.001. Control for parent's education level, children's language ability and general cognitive skills.

Discussion and Conclusion

- Home patterning activities took place 2-3 times a month on average. Arranging objects in patterns was the most frequent type of activity, while discussing patterns in time vocabulary was the least frequent activity. Interestingly, both activities were the two most frequent types of patterning activity in a similar study done in a South-eastern U.S. state (Zippert & Rittle-Johnson, 2020).
- Patterning activities were significantly positively correlated with children's patterning skills, and their math knowledge measured in the addition subtest and in the subscale of applications, even after controlling for parent's education level, children's language ability, and general cognitive skills.
- The Keymath – applications contains items assessing measurement, time and money, estimation, interpretation of data, and problem solving. The link between patterning skills and the two math aspects (i.e. addition and applications) may be explained by their shared reliance on understanding and detection of regularities.
- Patterning activities were also significantly positively correlated with parent's numeracy expectations and parent's attitudes to mathematics, controlling for parent's education level, children's language ability and general cognitive skills.
- This study suggests a possible influence of patterning activities at home on children's acquisition of mathematics knowledge.

References

1. Anders, Y., Rossbach, H. G., Weinert, S., Ebert, S., Kuger, S., Lehrl, S., & Von Maurice, J. (2012). Home and preschool learning environments and their relations to the development of early numeracy skills. *Early Childhood Research Quarterly, 27*(2), 231-244.
2. Bennett, J., & Müller, U. (2010). The development of flexibility and abstraction in preschool children. *Merrill-Palmer Quarterly, 56*(4), 455-473.
3. Connolly, A. J. (2000). *KeyMath: A Diagnostic inventory of essential mathematics*. Psycan.
4. Kidd, J. K., Carlson, A. G., Gadzichowski, K. M., Boyer, C. E., Gallington, D. A., & Pasnak, R. (2013). Effects of patterning instruction on the academic achievement of 1st-grade children. *Journal of Research in Childhood Education, 27*(2), 224-238.
5. Kidd, J. K., Pasnak, R., Gadzichowski, K. M., Gallington, D. A., McKnight, P., Boyer, C. E., & Carlson, A. (2014). Instructing First-Grade Children on Patterning Improves Reading and Mathematics. *Early Education and Development, 25*(1), 134-151.
6. Lam, Y. L. (2010). Evaluating an expressive language screening tool for five year. *Psychological Bulletin*, *114*, 495-509.
7. Lee, K., Ng, S. F., Bull, R., Pe, M. L., & Ho, R. H. M. (2011). Are patterns important? An investigation of the relationships between proficiencies in patterns, computation, executive functioning, and algebraic word problems. *Journal of Educational Psychology*, *103*(2), 269-281.
8. Lee, K., Ng, S. F., Pe, M. L., Ang, S. Y., Hasshim, M. N. A. M., & Bull, R. (2012). The cognitive underpinnings of emerging mathematical skills: Executive functioning, patterns, numeracy, and arithmetic. *British Journal of Educational Psychology*, *82*(1), 82-99.
9. Miller, M. R., Rittle-Johnson, B., Loehr, A. M., & Fyfe, E. R. (2016). The Influence of Relational Knowledge and Executive Function on Preschoolers' Repeating Pattern Knowledge. *Journal of Cognition and Development, 17*(1), 85-104.
10. Missall, K., Hojnoski, R. L., Caskie, G. I., & Repasky, P. (2015). Home numeracy environments of preschoolers: Examining relations among mathematical activities, parent mathematical beliefs, and early mathematical skills. *Early Education and Development*, *26*(3), 356-376.
11. Mulligan, J., & Mitchelmore, M. (2009). Awareness of pattern and structure in early mathematical development. *Mathematics Education Research Journal*, *21*(2), 33-49.
12. Niklas, F., Cohrssen, C., & Tayler, C. (2016). Improving preschoolers' numerical abilities by enhancing the home numeracy environment. *Early Education and Development*, *27*(3), 372-383.
13. Papic, M., Mulligan, J., & Mitchelmore, M. (2011). Assessing the Development of Preschoolers' Mathematical Patterning. *Journal for Research in Mathematics Education, 42*(3), 237-269.
14. Raven, J. C. (1958). *Standard Progressive Matrices: Sets A, B, C, D & E*. London: HK Lewis.
15. Rittle-Johnson, B., Fyfe, E. R., Hofer, K. G., & Farran, D. C. (2017). Early Math Trajectories: Low-Income Children's Mathematics Knowledge From Ages 4 to 11. *Child Development, 88*(5), 1727-1742.
16. Rittle-Johnson, B., Fyfe, E. R., Loehr, A. M., & Miller, M. R. (2015). Beyond numeracy in preschool: Adding patterns to the equation. *Early Childhood Research Quarterly*, *31*, 101-112.
17. Rittle-Johnson, B., Fyfe, E. R., McLean, L. E., & McEldoon, K. L. (2013). Emerging Understanding of Patterning in 4-Year-Olds. *Journal of Cognition and Development, 14*(3), 376-396.
18. Skwarchuk, S. L., Sowinski, C., & LeFevre, J. A. (2014). Formal and informal home learning activities in relation to children's early numeracy and literacy skills: The development of a home numeracy model. *Journal of Experimental Child Psychology*, *121*, 63-84.
19. Warren, E., & Miller, J. (2013). Young Australian Indigenous students' effective engagement in mathematics: The role of language, patterns, and structure. *Mathematics Education Research Journal*, *25*(1), 151-171.
20. White, C. S., Alexander, P. A., & Daugherty, M. (1998). The Relationship between Young Children's Analogical Reasoning and Mathematical Learning. *Mathematical Cognition, 4*(2), 103-123.
21. Zippert, E. L., Douglas, A. A., Smith, M. R., & Rittle-Johnson, B. (2020). Preschoolers' broad mathematics experiences with parents during play. *Journal of Experimental Child Psychology*, *192*, 104757.
22. Zippert, E. L., & Rittle-Johnson, B. (2020). The home math environment: More than numeracy. *Early Childhood Research Quarterly*, *50*, 4-15.