2022 Patterning Lens Pilot Structured Abstract

Background

Children's mathematics knowledge prior to formal schooling plays an important role in their future success. Mathematics knowledge at the beginning of kindergarten varies substantially and strongly predicts children's later mathematics and reading skills (Duncan et al., 2007; Goldstone & Sakamoto, 2003; Jordan et al., 2009; Spencer et al., 2021; Watts et al., 2014). In turn, individuals with weaker mathematics knowledge in childhood also tend to have lower incomes, attain less prestigious careers, and make poorer healthcare decisions as adults (Adelman & Education, 2006; Reyna et al., 2009; Ritchie & Bates, 2013).

Given the importance of mathematics knowledge, large achievement gaps in mathematics achievement between children from economically-disadvantaged versus advantaged homes is critical to address. Weak mathematics achievement in elementary school among economically-disadvantaged children is largely explained by their weak numeracy knowledge in kindergarten (Jordan et al., 2009). Indeed, early numeracy knowledge is foundational mathematics knowledge and is the focus of most early mathematics standards, instruction, and assessments (Jordan et al., 2009; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; National Research Council, 2009) as well as theories of early mathematics development (Fuson, 1988; LeFevre et al., 2010; Siegler, 2016; Steffe & Cobb, 1988). Thus, we must identify ways to better support children's early mathematics learning, especially their early numeracy learning and especially for economically-disadvantaged children.

Recent research suggests developing a patterning lens in preschool and kindergarten may be one promising way to improve numeracy learning. A patterning lens – the ability and tendency to look for and make use of predictable sequences – should help young children notice patterns in numbers and make use of those patterns to make predictions and to organize their numeracy knowledge (Zippert et al., 2020). For example, a patterning lens should help children learn predictable sequences in our number system such as the recursive count word sequence (Cheung et al., 2017), recursive base-10 place value notation (Resnick, 1989), and patterns in relations between number facts (Canobi et al., 1998) Indeed, children's patterning knowledge near entry to formal schooling uniquely predicts their later mathematics knowledge (Fyfe et al., 2019; Nguyen et al., 2016; Rittle-Johnson et al., 2017). Increasing evidence indicates that children's early patterning knowledge is related to their developing early numeracy knowledge in particular, controlling for many other variables, including fluid intelligence and relational reasoning (Papic et al., 2011; Rittle-Johnson et al., 2019; Wijns, Torbeyns, et al., 2019; Zippert, Clayback, et al., 2019; Zippert et al., 2020). There is also evidence that economically-disadvantaged children tend to have weaker patterning knowledge than children from more economically advantaged homes before they enter kindergarten (Rittle-Johnson et al., 2013; Starkey et al., 2004).

Purpose

The goal of the current pilot study was to refine our methods for a future intervention study aimed at improving economically-disadvantaged children's patterning lens, as well as further the development of our Early Patterning Assessment (EPA). The proposed intervention research that will be based off this pilot research will aim to advance theory by providing essential evidence (a) to refine a theory of how a patterning lens supports early numeracy learning and (b) to help test the causal contribution of this malleable factor to early numeracy learning. Such evidence would highlight the need to expand theories of early mathematics and numeracy development to include the role of a patterning lens. Most theories of early numeracy development focus on number-specific knowledge and sometimes consider general cognitive skills such as working memory, but do not consider the role of patterning knowledge (e.g., Fuson, 1988; Krajewski & Schneider, 2009; LeFevre et al., 2010; Siegler, 2016; Steffe & Cobb, 1988; Wright et al., 2006).

Setting

Data collection for the pilot study occurred at two local schools in Nashville in the Spring and Summer of 2022. Spring data collection occurred at an affluent private school in a metropolitan setting. Summer data collection occurred during a summer program at a Title I metropolitan school. Researchers met with students one-on-one in a quiet area.

Participants

Thirty-nine 5- and 6-year-old children across both schools (M = 6.51, SD = 0.38) completed pretesting as part of screening to be included in the 2022 intervention pilot study. Parents identified for their children, with 54% identifying as White, 28% indicating their child was of Color, and 17% choosing not to report. Finally, 20% of parents of participants indicated they do not speak English in the home.

Design

Pretest sessions lasted around 35 minutes. Participants completed three tasks at pretest: spontaneous focus on patterns (SFOP; Fyfe, personal communication, February 5, 2021), the Screener for Early Number Sense to assess numeracy knowledge (SENS; Jordan et al., 2010), and the Early Patterning Assessment – Repeating (EPA-R) to assess children's repeating patterning knowledge (Rittle-Johnson et al., 2020). In the SFOP task, researchers created a pattern on a paper dinosaur, and had children create the same pattern on their paper dinosaur. However, an error was made in our pilot study procedure that the researchers model dinosaur was visible while the participant created their dinosaur. The model dinosaur should have been shown to the participant, and then removed when it was time for the participant to create their dinosaur. A posttest session consisting of the same tasks occurred roughly two weeks after pretest. For students who did not pretest out, defined as at or above 80% correct on both patterning (i.e., EPA-R) and numeracy (i.e., SENS), during the two weeks between pre- and posttest, participants received 5 patterning + numeracy tutoring sessions.

Results

For the purposes of this report, results focused on performance at pretest. At pretest, internal reliability was good for the EPA-R, $\alpha = 0.81$, and SFOP, $\alpha = 0.77$. A strong correlation was found between children's pretest repeating patterning and numeracy knowledge, $r(36)$ =

.464, $p < .01$, however no significant correlations were found between children's pretest patterning and SFOP performance, or between children's pretest numeracy knowledge and SFOP performance. Test-retest reliability for the EPA-R was good, as the correlation between children's patterning performance at pre and posttest was $r(17) = 0.71$. Consistent with our prediction and previous research conducted on the EPA, unit ID items tended to be more challenging than completion, ID, and abstract items (see Figure 1). In contrast to our prediction, completion, ID, and abstract items were all of similar difficulty levels. Finally, when looking at differences in performance across the two schools at pretest, children did not differ significantly in their patterning knowledge (Private = 15.8/20, Title I = 15.2/20) or numeracy knowledge (Private = 16.95/20, Title I = 18.1/20).

Conclusions

A strong correlation was found at pretest between children's patterning and numeracy knowledge, consistent with research highlighting how the two skills are related. Further, the EPA-R appears to be a reliable measure for assessing children's patterning knowledge, and the revisions made to the unit ID items for this version of the EPA worked well compared to previous iterations.

Figure 1

Wright Map Showing Distribution of Participants Patterning Knowledge and Item Difficulties on the Same Scale

Frequency of Participants (greater knowledge at top)	Map	Items (hardest at top)			
	2				
x					
	1.5				
xxxxxxx		UnitID_ABCD	Unitid_AB	Unitid_AABB	
	1				
xxxxx					
	0.5				
xxxxxxx					
	0				
xxxxxx		Extend_ABC	Unitid_ABC		
	-0.5				
xxx		ID_AABB	Abstract_ABCD		
	-1				
xxxxxxx		ID_ABB	Completion_ABB	Extend_AB	Extend_ABCD
	-1.5				
xx		Extend_AAB	Abstract_AB	Abstract_AAB	Abstract_AABC
	-2				
		Completion_ABCC			
	-2.5				
		ID_nonpattern	ID_nonpattern	Completion_AB	
	-3				
		Completion_ABC			
	-3.5				

Construct Map (hardest at top)
Unit ID
Abstract
Completion and Extend
ID

Note. Each "x" represents one participant. Participants at the top have greater knowledge and items at the top are more challenging.