Children’s Identification of a Novel Visual Alphabet Relates to Their Spatial Skills
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Short Abstract
This study highlights the insufficient focus on spatial skills education in schools, contributing to disparities in spatial training access. It introduces the Pattern Alphabet, a visual tool designed to familiarize children with spatial thinking through 32 shapes and forms found in nature and human-made artifacts. Results revealed children’s identification of shapes and forms in the pABC and their spatial skills were related, suggesting pABC training could foster inclusivity in both formal and informal educational settings.

Long Abstract
Introduction
Everyday tasks, such as assembling furniture and packing a carry-on bag, rely on spatial skills, or the ability to mentally and physically manipulate information about space and objects. Spatial skills are crucial for success in STEM disciplines (Wai et al., 2009), and are most malleable in early childhood (Uttal et al., 2013; Verdine et al., 2014). However, schools inadequately teach spatial skills (Rocha et al., 2022). By age 3, children from higher-resourced families consistently have more access to spatial activities and language than children from lower-resourced families (Levine et al., 2012; Verdine et al., 2017). Additionally, gender differences in children’s experience with spatial activities and spatial language are significant by preschool, favoring boys (Jirout & Newcombe, 2015; Pruden & Levine, 2017). What if these disparities could be addressed by familiarizing children with common shapes in the world? A new tool born from art and design—the Pattern Alphabet (pABC; Wolf et al., 2022)—aims to familiarize children with spatial thinking through 32 shapes and forms found in nature and human-made artifacts (e.g., circle, symmetry). The pABC is composed of four categories: (1) Growth illustrates natural growth with forms such as explosions and spirals; (2) Geometry illustrates geometric shapes, such as triangle and octagon; (3) Symmetry illustrates various forms of symmetry, such as bilateral symmetry and asymmetry; and (4) Building Blocks illustrates the basic forms that enable the creation of new shapes through points and angles. Here we ask: (1) Can children identify shapes and forms features in the pABC without training?; and (2) How do children’s identification of pABC forms relate to their spatial skills?

Method
Eighty-nine children (45 girls, $M_{age} = 58.71$) from largely homogenous backgrounds (66.3% white; 93.3% with a parent with a bachelor’s degree) were individually tested remotely through Zoom from their homes. To administer the study, the experimenter shared their screen, and all games were completed in the same order. First, children completed the pABC Match-to-Sample Task, which featured a subset of pABC forms as some items on the pABC require more mathematical understanding than young children possess (e.g., fraction, angle). Therefore, children saw 27 trials and were asked to select which one of three photographs most resembled a black-and-white lined form from the pABC (e.g., picture of the Earth matched with circle). Second, children completed the Woodcock Johnson III Spatial Relations (WJ-III SR; Schrank et al., 2014), where they selected between two and three component pieces that, when put together, would replicate a design. Third, they completed the Preschool Early Numeracy Sense Screener—Brief Form Virtual (PENS-B; Purpura et al., 2015), where they identified numbers and
Results

Two independent samples t-test with a Bonferroni adjusted alpha level of .025 per test (.05/2) revealed there was no significant difference in performance across genders on the Match-to-Sample (p = .393) nor on the WJ-SR (p = .279). Thus, data were collapsed on those two variables on subsequent analyses. We first tested whether children could match photographs of natural and human-made artifacts to outlined pABC forms without receiving any training. Descriptive statistics revealed that children accurately matched most of the pABC forms (M = 23.04, SD = 3.01, Range = 13-27).

To assess whether there were differences in children’s matching of different pABC categories, a one-way ANOVA was conducted. Results revealed that there was a statistically significant difference between performance across the four categories (F(3,312) = 17.205, p < .001). A Tukey post hoc test revealed no statistically significant differences in performance between the Growth (M = .88, SD = .14), Building Blocks (M = .88, SD = .19), and Geometry (M = .93, SD = .13) categories (all ps > .100); however, results did reveal that children matched significantly fewer forms in the Symmetry category (M = .76, SD = .17) compared to the Growth, Building Blocks, and Geometry categories (all ps < .001).

To explore the relationship between performance on the pABC Match-to-Sample and WJ-SR, a multiple regression analysis was performed using overall performance on the Match-to-Sample and age as the predictor variables and WJ-SR as the outcome variable. The model was significant and accounted for 11.3% of the variance, F (2, 73) = 4.64, p = .013. Match-to-Sample performance predicted performance on the WJ-SR (β = .283, p = .015) over age (p = .283). To investigate whether performance on particular pABC categories predicted performance on the WJ-SR more than others, a multiple regression using performance on the four pABC categories and age as the predictor variables and performance on the WJ-SR III as the outcome variable was significant and accounted for 15.6% of the variance, F (5, 73) = 2.70, p = .027. Only performance on the Growth trials significantly predicted performance on the WJ-SR (β = .261, p = .047), suggesting that recognition of non-standard shapes and forms is more predictive of spatial performance than recognition of geometric forms children are familiar with.

Discussion

Results indicated that children, even without prior training, could accurately match most pABC forms, with variations in performance across different categories. Notably, children displayed lower matching rates in the Symmetry category compared to others, signaling a potential need for additional training to enhance understanding of the concept of symmetry (Valenzeno et al., 2003). Importantly, children’s performance on the pABC Match-to-Sample task predicted spatial skills, with the Growth category standing out as the sole significant predictor. This suggests the potential benefits of a pABC-based curriculum that incorporates diverse shapes and forms beyond standard and familiar geometric forms could enhance children’s spatial abilities. The best aspect of the pABC is that it invites children to see their environment in a new way, promoting inclusivity and personalized spatial training in formal and informal educational settings.
References


