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The Effects of in-class tutoring of Kindergarteners on Patterning, Reading, or Mathematics

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Abstract

Kindergarten students were pretested on the Dynamic Indicators of Basic Early Literacy Skills (DIBELS), the Assessment of Basic Language and Learning Skills - Revised (ABLLS-R), and Woodcock-Johnson III (WJ-III). Following testing, the students were randomly assigned to tutoring groups which focused on patterning, reading, mathematics or social studies (control). The children were tutored in pairs or trios, and an undergraduate student who was earning course credit for his or her work led the tutoring sessions. Each tutoring session lasted about 15 minutes, and the sessions occurred in three to five times per week during the spring semester. When post-tested in June, the children tutored in literacy scored significantly better than any others on the DIBELS Letter Knowledge scale. The children taught patterning outscored those taught social studies on the DIBELS First Sounds time measure. These results suggest that tutoring from undergraduate students can be an effective method for providing extra support to children struggling in reading.

1.1 Introduction

Patterning instruction (i.e., instruction focusing on the alternating presentations of colors, shapes, or objects) is traditionally a part of early childhood education. Such instruction begins with simple ababab patterns such as red blue red blue red blue, and becomes increasingly complex. This subject matter has been taught across the USA for the last half-century, and many educators still view it as a necessary foundation for elementary school mathematics (National Council of Teachers of Mathematics, 1993; National Association for the Education of Young Children/National Council of Teachers of Mathematics Education, 2002/2010). Patterning is thought to improve young children's understanding of mathematics (Baroody, 1993; Clements &Sarama, 2007, a,b,c; Threfall,1993; Warren, Cooper, & Lamb, 2006); however, empirical evidence that instruction in patterning contributes to young children's understanding of mathematics is sparse.

The limited research supporting the importance of patterning instruction for children's mathematical development includes a recent longitudinal study done by Fyfe, Rittle-Johnson, Hofer and Farren (2015). Significant regression coefficients (.17-.18) were found between children's performance on patterning measures as preschoolers and their performance on a mathematical composite score. Another correlational study done by White, Alexander, and Daugherty (1998) found a strong correlation (.56) between preschoolers' ability to extend alternating patterns and their scores on analogical reasoning as measured by the Georgia Kindergarten Assessment Program (GKAP). Both of these studies support the conclusion that an early understanding of alternating patterns is related to later mastery of mathematics. However, there was no instructional component to these studies, and correlational studies alone cannot prove causality. A more direct approach is to instruct children in patterning and to then measure the resulting benefits on mathematical ability.

Although there have been many studies of curricula which include patterning, there have been only two studies of instructing preschoolers in patterning and one study of the effect of instructing kindergartners in patterning. Miller, Rittle-Johnson, Loehr and Fyfe, (2015) reported the effect of very brief patterning instruction (two sessions of about 15 minutes) on four-year-old children. The children, who were primarily middle- and upper-middle-class, did not show significant improvement in duplicating or extending alternating patterns. They did become significantly better at abstracting patterns (i.e., the child was shown a pattern in shapes, and asked to make the same pattern with colors, or vice versa). The authors hypothesized that the children may have made gains on abstracting patterns and not corresponding gains on other types of patterning work because the intervention specifically focused on abstracting patterns. Instruction by an adult, self-instruction, or a combination of the two made no lasting difference in the children's performances.

Papic, Mulligan, and Mitchelmore (2011) offered preschoolers more extensive patterning instruction (12 30-minute sessions). In addition to conventional alternating patterns, the children were taught patterns in which elements alternated in more complex ways. They also received six sessions of instruction on a variety of spatial structure tasks. Although the experimental children's patterning scores were lower in an absolute sense than those of the control children at the outset of the experiment and they made higher scores at the end, no statistical comparisons were made because the two samples were not randomly selected. The control children were from a different preschool. Hence sample differences, or differences in teachers, curricula, or other factors, could have accounted for the differences in their scores.

The only study of the effect of patterning instructions on kindergarten students is that of Herman (1973), who gave African-American and Spanish-speaking inner-city children 24 lessons on alternating patterns. The African American children receiving these lessons scored significantly better than control children on a patterning test and on a standardized test of mathematics achievement. However, as was the case with Papic et al. (2011) the control children were from a different school. Again, pre-existing differences in the two samples of children, or their teachers, curricula, school, etc., could account for the differences in test scores.

Hence, the evidence that teaching patterning in preschool or kindergarten produces gains in academic achievement is not convincing. However, that is not the case for teaching patterning to first graders. Hendricks, Trueblood, and Pasnak (2006) randomly assigned first grade children to matched 15-minute lessons on either academic material recommended by their teachers as or on patterning. The 400 patterns used were more complex than alternating patterns: bead patterns in 6 – 8 colors, number and letter patterns, and graphic patterns. After four months of this parallel instruction on either patterns or academic subject matter, the children taught patterning outscored the others on Diagnostic Achievement Battery measures of mathematics and written language. More recently, researchers have compared first grade children randomly assigned to receive thrice weekly instruction for approximately five months on either complex patterns similar to those Hendricks et al. (2006) employed, mathematics, reading, or social studies (Kidd, et al. 2013; Kidd, et al. 2014; Pasnak, et al. 2015). Although results varied somewhat across experiments and tests, the children taught patterning scored as well or better on two standardized tests of mathematics than those taught mathematics or social studies. They also scored as well on reading as those taught reading, and better on three standardized reading tests than those taught mathematics or social studies. Hence, teaching patterning improves reading as well as mathematics, a development predicted by Sarama and Clements (2004) and Fox (2005). However, the patterns used in these tests of patterning instruction for first graders were more complex than those commonly used in instructing kindergartners.

This study sought to fill a hole in the research, and to examine the impact of patterning instruction on the mathematical and reading abilities of kindergarten students. Such a design would allow comparison of equal investments of time and resources in these subject matters, and hence show whether patterning instruction deserves the time spent on it in kindergarten curricula, or whether the time could be better devoted to additional time spent on literacy or mathematics. Accordingly, an experiment was designed similar to those of Kidd et al. (2013), Kidd et al. (2014), and Pasnak, et al. (2015). Kindergarten children from the same school and classrooms were randomly assigned to receive 15-minute sessions of instruction on either patterns, reading, mathematics or social studies (control).

1.2 Hypotheses

The first hypothesis was that the children taught mathematics would do better on a standardized mathematics test than those taught reading or social studies.

The second hypothesis was that the children taught reading would do better on a standardized test of reading than those taught mathematics or social studies.

The third hypothesis was that the children taught patterns would do better on standardized mathematics and reading tests than those taught mathematics, literacy, or social studies.

2. Method

2.1 Participants

Parents gave written consent for 73 kindergartners from six classrooms in a suburban Virginia school to participate. The 64 students who scored the lowest on a patterning test were selected to participate in the research. After attrition, there were 24 girls and 30 boys.

2.2 Materials

2.2.1 Standardized Tests

Reading was measured via the Dynamic Indicators of Basic Early Literacy Skills (DIBELS).The DIBELS is an assessment measuring skills necessary for reading success in Kindergarten through 6th grade. The Initial Sound Fluency and the Letter Naming Fluency subtests were given. Benchmark 2 was used for the pretest and Benchmark 3 for the posttest. In the Initial Sound Fluency assessment children were required to name as many letters as they could from a list in one minute or less. Their score was the total number of correctly identified letters. In the Letter Naming Fluency assessment children were required to answer a series of questions about which picture began with a specific sound. They received two scores: the number of correct responses and the total time (in seconds) that it took them to finish the assessment.

Validity tests of the DIBELS yielded a correlation coefficient of .34 (December) and a correlation coefficient of .44 (April) with the Woodcock Johnson Readiness Cluster Score. Additionally the DIBELS has a correlation coefficient of .41 (December) and a correlation coefficient of .29 (April) with the Stanford-Binet Verbal Reasoning Standard Score. Mathematics was measured with scales 18A and B Quantitative Concepts from the Woodcock-Johnson Tests of Cognitive Abilities III (WJ). Scales 18A and 18B assess a student’s understanding of mathematical symbols, concepts, vocabulary, and number sequences. Administration was discontinued when a child made four consecutive incorrect responses for 18A, and three for 18B. The number of problems answered correctly on a given scale was the child’s score for that scale.

The WJ has convergent validity coefficients of .62-.66 with the Kaufman Test of Educational Achievement and .68-.70 with the Wechsler Individual Achievement Test.Patterning was measured with a portion of the Assessment of Basic Language and Learning Skills - Revised (ABLLS-R). The ABBLS-R is an assessment measuring the language and learning skills necessary for success in Kindergarten. Only the targets specific to understanding patterning (from the visual picture match to sample section) were assessed. Children were required match patterns, to complete patterns, to replicate patterns, to replicate patterns with a delay and to fill in the blanks for patterns. The children were assessed on their ability to complete these tasks with ABAB patterns, AABAAB patterns, ABBABB patterns and ABCABC patterns. Ceiling was reached after one incorrect response to any of the targets. The number of correct targets was totaled, and the total raw number of correct targets was used to obtain a patterning score on the assessment for analysis. The validity of the ABBLS-R is high, with a correlation coefficient of .83 with the Vineland Adaptive Behavior Scales age equivalents and a correlation coefficient of .90 with the Mullen Scales of Early Learning age equivalents.

2.2.2 Instructional Materials

Crayons, plastic letters and numbers, playdough, construction paper, a variety of small objects which could be counted, and worksheets covering various topics from the social studies curriculum were used for the instruction.

2.3 Procedure

Supervised undergraduate research assistants administered aforementioned subtests of the ABLLS-R, the WJ-III, the DIBELS letter naming assessment, and the DIBELS first word sounds assessment in counterbalanced order in October-December. The 64 children scoring lowest on the ABLLS-R were selected as the sample. Pairs of these children from each of six classrooms (or trios, if enough had received parental permission) were randomly assigned to receive patterning, reading, mathematics, or social studies instruction. Undergraduate college students supervised by graduate students met with and tutored each group of kindergarten students between 15-25 times throughout the spring semester. The majority of students were met with at least 20 times during the spring semester. This tutoring took place during the "centers" time reserved in the curriculum for small group work or during the circle time in the morning.

The patterning instruction was modeled after the interventions employed by Kidd et al. (2013), Kidd et al. (2014) and Pasnak, et al. (2015). The children worked on completing, filling in, reproducing and creating patterns of numbers, shapes, or letters, rotations of an object and objects. The children given mathematics instruction were taught number identification, numerical conceptualization and addition facts (0-10). The children in the reading condition were taught letter identification, letter sound identification, handwriting, reading comprehension and story re-telling (i.e., tell me the story of The Three Little Pigs). The children given social studies instruction (control group) completed coloring and writing worksheets concerning various topics covered in the social studies curriculum. The graduate student managers assessed the college students weekly for competency in the implementation of the different forms of tutoring using a competency checklist. In June, the ABLLS-R, DIBELS, and the WJ-III were read ministered in a counterbalanced order.

3. Results

Descriptive statistics are given in Table 1. There was a significant main effect of instructional condition on the DIBELS Letter Naming scale, $F(1,51) = 2.19$, $p < .001$. Planned comparisons (LSD) showed that the children in the reading group scored significantly better (i.e., named more letters accurately) than those in the social studies and mathematics groups. There was also a significant main effect of the instructional condition on the time measure of the DIBELS First Sounds scale, $F(1,51) = 16.13$, $p < .001$. Using a one-tailed test of significance the patterning group scored higher (i.e., were faster to answer correctly) than the children in the control group $p<.05$.

4. Discussion

This is the first experiment in which kindergartners from the same school were randomly assigned to receive patterning instruction. Thus, the effects of teachers, school variables and classrooms were equalized. Furthermore, the use of active control groups, wherein the comparison children received tutoring matched in timing and frequency to that of the children tutored in patterning, equalized the effects of attention, expectations, and investment of resources. It is clear that the both the reading tutoring and patterning tutoring had limited effects on the achievements of the children. The children who received the reading tutoring improved most on the DIBELS Letter Naming Scale. They were significantly better than the children who received tutoring on mathematics or social studies. Furthermore, the direction of the difference favored them over the children who received patterning instruction, although it was not significant. Hence, the reading instruction provided advantageous support for children who were struggling with reading at the time of the posttest.

Children in the patterning group scored better on the time measure of the DIBELS First Sound Scale (i.e., were able to answer the questions faster) than children in the social studies group. The latter children were always designated as a control group, receiving the same amount of attention and tutoring in achievement-oriented subject matter as the other children. One of the negative findings from this research was that the tutoring in mathematics had no significant effects. The most likely reason for this is that the classroom teachers' instruction surpassed that accomplished by the college student tutors. Indeed, although the children were selected from those who scored worst on the patterning pretest, the average posttest score for the kindergarteners from each of the tutoring conditions on the WJ-III subtests was 1:2 for the kindergartners from each of the tutoring conditions. Hence, the teachers had done a fine job of teaching these kindergartners mathematics, and the tutoring did not improve upon it. Another negative finding was that, although the children tutored in patterning scored higher than any other group on the patterning test, the differences were not significant. This was probably a measurement problem.

The ABLLS-R captures many aspects of children's understanding of simplistic alternating patterning problems, but much of the patterning tutoring was devoted to more complex patterning problems. Had a test of children's understanding of complex patterns been employed here, the outcome might have been different. Another issue, previously raised by Rittle-Johnson et al. (2015), may have obscured the impacts of patterning instruction. This study summarized parent survey results and found that parents engage with their children in patterning activities at least once per week. Teaching alternating patterns was also a part of the curriculum that the teachers offered to all of their students. These two factors probably accounted for the similarity of the children's scores on the ABLLS-R alternating pattern measure. Future work should be sure to include instruction beyond what teachers and parents customarily teach.

5. Summary and Conclusions

Tutoring pairs or trios of kindergartners in early literacy had a measurable effect on the children's knowledge of letters, and tutoring them on complex patterns reduced the duration of time which it took the children to complete questions concerning the first sounds of letters. The latter finding confirms the suggestions of Sarama and Clements (2004) and Fox (2005) that patterning could improve literacy. No effects were found on mathematics scales. More robust results probably require tests more appropriate to the children's final level of performance, instruction that surpasses that offered by teachers and parents, or samples of 5-year-olds who have not been exposed to such instruction.

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