Abstract Title Page

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Title: A Teacher-Friendly Method of Improving Reading and Mathematics

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Abstract Body

Limit 4 pages single-spaced.

Background / Context:

In early elementary school in most English-speaking countries children are taught "patterning," which involves learning repetitive patterns of colors or shapes (e.g., red, blue, green, red, blue, green). Such instruction could be extended to other countries, because patterning is essentially culture-free. It is easy for teachers to do, most are quite practiced in doing it, and several instruction manuals exist (Burton, 1982, Jarboe & Sadler, 2003, Ducolon 2000).

One dissertation (Herman, 1973) and one small-scale study (Hendricks, Trueblood, & Pasnak, 2006) indicate that patterning instruction affects academic achievement, but these studies are flawed and there is little other empirical evidence that it actually improves children's learning of academic subject matter. However, Clements and Sarama (2009, 2007a,b,c,) and others have theorized that understanding patterns is the beginning of prealgebra and they have made patterns integral to their successful Building Blocks program. It continues to be taught in most American schools. "If you ask any kindergarten teacher, he or she is likely to consider the study of patterns to be an essential part of the mathematics program" (Economopolous, 1998). However, the National Mathematics Advisory Panel (2008) has recommended that it be de-emphasized in future curricula.

Purpose / Objective / Research Question / Focus of Study:

The present study was designed to test the effectiveness of patterning instruction when compared to equal amounts of instruction in reading or mathematics, or social studies. Further, we tested the effectiveness of using more complex patterns than the simple alternations conventionally taught. Hence, we used (1) symmetrical patterns – gray, blue, pink, pink, blue, gray – and (2) patterns that had increasing numbers of one element –red, tan, red, tan, tan, red, tan, tan, tan – and (3) arbitrary repeating patterns – white, green, black, brown, yellow, white – and (4) patterns which showed an object rotating through 6 or 8 positions.

Setting:

The study was conducted in all of the first grade classrooms in five elementary schools in an urban setting in northern Virginia.

Population / Participants / Subjects:

443 first-graders were screened in October on a 42-problem patterning test. 140 with poor scores were selected for the research ($M = 13.17$, $SD = 4.22$). After attrition, 120 children remained, 64 boys and 56 girls. Of these, 52 (43%) were African American, 42 (35%) were Hispanic/Latino, 16 (13%) were Middle Eastern, 3 (2.5%) were Caucasian, and 7 (5.8%) were of an unspecified ethnicity. The mean age for these children was 6 years 5.19 months, SD = 3.36 months. 57% received free or reduced priced lunches due to low family incomes.

Intervention / Program / Practice:

Overview. The eight children in each classroom who scored lowest were selected for the research. A random numbers table was used to assign two to patterning instruction, two to reading instruction, two to mathematics instruction, and two to social studies instruction. These children were taught the subject they were assigned to – either patterning or mathematics or reading or social studies – for 15 minutes three times per week during "centers time," an hour or so devoted to individualized or small group activities in all first grade classes in this school system, from November through April. The order of instruction was counterbalanced, so that teachers engaged in each form of instruction first, second, third, or fourth equally often.

In May, school psychologists, who were blind to the condition to which children had been assigned, re-administered the original screening test, and gave seven more tests to each child - the GORT, the TOWRE, the TERA, the W-J Math Concepts scales A and B, the Key Math test, and the "far generalization" patterning test.

Patterning Instruction. Patterns, which were symmetrical patterns, progressions with increasing numbers of elements, sizes, or values, rotations, and arbitrary repeating patterns, were displayed on note cards, white boards, table tops, or minicomputers. Each pattern had a missing element in the beginning, middle, or end of the pattern. Each problem displayed four options for completing the pattern, and the children were asked to identify the option that completed the pattern. Performance was scaffolded through explanation and repetition until each child was able to demonstrate mastery of each pattern by selecting the correct option on their first attempt on three consecutive sessions.

In addition to identifying the missing element in a pattern, children were taught to use manipulatives (small objects) to extend patterns. Teachers would start a pattern, provide the children with more manipulatives, and request that they complete or extend it. Children were also asked to create patterns to be completed by the teacher or another child. White boards were also employed for these purposes. The only difference was that patterns were drawn on the boards instead of being made from manipulatives.

Mathematics Instruction. Each mathematics lesson featured a different kind of activity, such as counting by fives and tens, addition, recognizing and naming shapes, and understanding simple fractions. First, the teacher did a brief assessment of whether the children had the fundamental abilities needed to perform the chosen task. If needed, there were fall-back or jump ahead options so that the teacher could match the activity to the best starting point for that day. After the day's instruction had been accomplished, it was concluded with a task or question addressing the overarching point of the activity.

There were necessarily many math activities during the school year, and these were very variable. An example of this type of activity was counting. The session began with children quickly counting to 100 as a review. This was followed by a task wherein the children were to pick up in order cards numbered 1 to 100, which had been spread out in front of them in a scattered, disorganized array. The activity could be made easier by reducing the number of cards to 25 or even ten, or extended by asking the children to pick up the cards in reverse (decreasing) order. The teacher would direct and scaffold as necessary. If this was too difficult, the number cards 1 through 20 were used. The final activity was to put the cards away in deciles, i.e., first collecting all of the cards between 0 and 10, then all of the cards in the teens, then all of the cards in the 20s, etc.

Reading Instruction. A brief children's poem with a targeted end rhyme (e.g. -own) was the focus for each week's three sessions. The sessions began with a minute or so of discussion to put the children at ease and improve conversational skills. Then each child read aloud the poem that had been the focus the previous week, using a Whispy Reader to avoid disturbing the other children. This reading of material already covered was designed to improve comprehension and fluency and to teach sight words and decoding. The teachers helped the children as much as needed and queried them with questions about the familiar poem they were reading to solidify their comprehension of it. This took approximately three minutes.

The next six minutes of the session were devoted to the week's new poem and varied according to the three sessions for that week. On the first day, the teacher read the poem aloud and talked to the children about what they had just heard, trying to improve comprehension. On the second day, the teacher and children read the poem together. The teacher emphasized fluency and discussed unfamiliar words in the poem to improve the children's vocabulary. On the third day, the children read the poem alone as well as they could, and brief discussion and questioning were employed to improve comprehension, fluency, and vocabulary. Rhyming word flashcards that had the same end sound as the week's poem were then used for four minutes in a phonics activity. Teachers helped the children to recognize the identity between the end sounds in the poem and the end sounds of the words on the cards.

Each session ended with a minute spent by the teacher and children summarizing what had been attempted and accomplished during the session.

Social Studies Instruction. Social studies activities changed daily and featured a variety of activities that highlighted civics, geography, and important people and events in history. The instructor would join the children in different activities such as coloring activity sheets, making collages, and so forth, which was typical for social studies instruction in this school system.

Research Design:

In essence, we had one experimental condition (patterning) and three control conditions: reading, mathematics, and social studies. Children were randomly assigned to these conditions. Each classroom teacher had the same number of children in each condition, so teacher and classroom effects were controlled, but the children were randomly assigned to the form of instruction they received, avoiding subject bias. There were positive expectancies for every child, as all received useful forms of instruction, which also controlled Hawthorne effects.

Data Collection and Analysis:
In May, school psychologists, who were blind to the condition to which children had been assigned, re-administered the original screening test, and gave seven more tests to each child - the GORT, the TOWRE, the TERA, the W-J Math Concepts scales A and B, the Key Math test, and a "far generalization" patterning test. Analyses were one way ANOVAs followed by planned comparisons of groups.

Findings / Results:
There were no significant differences among the four groups on the number of items correct on the screening test -$F(3,116) = 0.24$, $p > .05$ – indicating that random assignment created an equivalent groups design. Repeated measures ANOVA showed that differences between the dimensions were trivial, $F(3,256) = .02$, $p > .05$. This echoed the findings of Gadzichowski, Kidd, Pasnak, & Boyer (2010) for similar patterns. There were also no significant differences for the orientation of the patterns, $F(1,118) = .04$, $p > .05$, or the position of the missing item, $F(2,237) = 1.69$, $p > .05$. Hence these variables were collapsed. We subsequently assessed performance on the reading and mathematics scales.

The patterning group performed significantly better than each of the other groups on the patterning posttest and the patterning far generalization test (please insert Table 1 here). On the TOWRE Word and TERA measures of reading, the patterning group attained the highest scores in an absolute sense, but the patterning and reading groups did not differ significantly. Both achieved significantly higher scores than the other two groups. On the GORT, the only differences were that the patterning group was superior to the mathematics and social studies groups. There were no significant differences on the TOWRE phonemics scale (please insert Table 2 here).

The patterning and mathematics groups were both significantly better than the other groups on the W-J Mathematics Concepts Scales (please insert Table 3 here). Mean scores for the patterning group were always higher than for the other groups on the Key Math scales, and the differences on all except Geometry and Multiplication were significant (please insert Table 4 here).

Conclusions:

The patterning instruction involved patterns that were more complex than those used in conventional patterning instruction. The instruction continued all year, and required individual mastery of each pattern before moving on to the next. We think it is unlikely that a few weeks of whole class instruction on simple alternation or double alternation patterns, which is recommended and conventional at younger ages (National Council of Teachers of Mathematics, 1993), would have produced the outcomes (up to eight months advantage on some measures) that we found.

The mechanisms by which an improved ability to understand patterns leads to better reading and mathematics achievement have not been demonstrated, despite the contributions of Papic (2007), Threlfall (2004), White et al. (1998), the Clements and Sarama team, and others. Our study was an empirical test of whether such instruction profited children academically, and adds substantial evidence to that provided by the earlier reports of Herman (1973) and Hendricks et al. (2006). It did not, however, provide any test of the cognitive mechanisms involved. Hence, there remains much work for theorists in education and cognitive development.

Finally, patterning did not produce advantages on the TOWRE phonemics measure or the Key Math Geometry or Multiplication scales, nor was the patterning group's advantage on the other scales consistent. Presumably all of the significant differences resulted from the children who received patterning instruction being able to better understand and apply the ongoing classroom instruction in mathematics and reading. It remains to be determined why this better understanding would show up on some scales and not others from the same standardized tests.

A gain of even two months in grade equivalents has great practical significance to educators, and the patterning children often made gains much larger than that. Hence, the implications are that for those children who have relatively poor understanding of patterns. Long-term instruction on and mastery of increasingly complex patterns can lead to substantially improved performance on some standardized tests of reading and mathematics, but not all. Future research might involve systematically varying the ability levels of the children who received patterning instruction, varying the patterns that the children were taught, varying the way in which they were taught, and varying the measures of academic achievement employed to assess the instruction's effects. Fuller theoretical explanations of just what thinking abilities are improved by patterning instruction should be developed, and the connections between those thinking abilities and reading and mathematics should be elucidated. Much remains to be done – enough to occupy researchers for a long time to come.

Appendices

Not included in page count.

Appendix A. References

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Appendix B. Tables and Figures

Table 1

Descriptive Statistics for Patterning Screening Test, Posttest, and Far Generalization Test

Test	Group	Mean	SD
Patterning Screening			
	Patterning	11.32	3.93
	Reading	11.35	3.69
	Mathematics	11.27	3.24
	Social Studies	10.69	2.88
Patterning Posttest			
	Patterning	27.68	8.34
	Reading[a]	15.61	5.01
	Mathematics[a]	12.60	3.42
	Social Studies[a]	14.66	6.59
Patterning Far Generalization Test			
	Patterning	7.90	2.89
	Reading[a]	4.58	2.28
	Mathematics[a]	4.37	1.71
	Social Studies[a]	4.55	2.35

Note. Superscripts denote p <. 001 on independent a priori comparisons with Patterning[a]

Table 2

Descriptive Statistics and Grade Equivalents for Reading Tests

Test	Group	Mean	SD	Grade Equivalent
TOWRE Word				
	Patterning	49.52	13.22	2.8
	Reading	42.45	15.19	2.4
	Mathematics [a,b]	32.93	13.31	2.0
	Social Studies [a,b]	33.31	17.33	2.0
TOWRE Phonemics				
	Patterning	16.26	12.19	2.2
	Reading	15.10	9.98	2.0
	Mathematics	13.03	10.04	2.0
	Social Studies	15.59	12.64	2.0
GORT				
	Patterning	13.71	6.78	2.0
	Reading[a]	8.42	6.20	1.4
	Mathematics [a]	9.97	6.08	1.6
	Social Studies [a]	9.83	6.68	1.6
TERA Meaning				
	Patterning	19.58	4.95	1.4
	Reading	17.35	5.02	1.2
	Mathematics [a,b]	14.27	4.74	1.0
	Social Studies [a,b]	13.17	4.43	1.0

Note. Superscripts denote p <. 05 for a priori independent comparisons with Patterning[a] or Reading[b]

Table 3

Descriptive Statistics for Woodcock-Johnson Mathematics Concepts Scales

Scale	Group	Mean	SD
W-J Mathematics Concepts (A)			
	Patterning	15.00	.73
	Reading [a,b]	10.87	2.45
	Mathematics [a]	13.90	1.35
	Social Studies [a,b]	8.76	2.10
W-J Mathematics Concepts (B)			
	Patterning	16.48	1.88
	Reading [a,b]	10.68	3.50
	Mathematics [a]	12.87	2.46
	Social Studies [a,b c]	9.21	1.05

Note. The manual does not provide grade equivalencies for these scales. Superscripts denote p <. 02 for a priori independent comparisons with Patterning[a] or Mathematics[b] or Reading[c]

Table 4

Descriptive Statistics and Grade Equivalencies for Key Math Achievement Scales

Scale	Group	Mean	SD	Grade Equivalent
Key Math Numeration				
	Patterning	13.19	3.40	2.0
	Reading [a]	10.29	3.90	1.4
	Mathematics [a]	10.83	4.25	1.6
	Social Studies [a]	10.79	3.54	1.6
Key Math Addition				
	Patterning	10.09	2.87	2.2
	Reading [a]	7.32	2.86	1.6
	Mathematics [a]	7.80	3.31	1.9
	Social Studies [a]	7.93	3.02	1.6
Key Math Algebra				
	Patterning	9.16	3.44	2.4
	Reading [a]	7.03	3.22	1.8
	Mathematics [a]	6.90	3.35	1.8
	Social Studies [a]	7.24	3.81	1.8
Key Math Measurement				
	Patterning	11.51	4.43	2.3
	Reading [a]	8.71	4.42	1.6
	Mathematics [a]	9.00	4.72	1.7
	Social Studies [a]	8.93	4.54	1.7
Key Math Foundations				
	Patterning	8.26	2.32	2.3

Reading [a]	6.35	2.18	1.6
Mathematics	7.37	3.23	1.9
Social Studies [a]	6.48	2.96	1.6
Key Math Computation			
Patterning	8.39	3.47	2.2
Reading [a]	6.23	3.77	1.0
Mathematics [a]	6.00	3.45	1.0
Social Studies	6.79	3.96	1.2
Key Math Data Problems			
Patterning	9.84	4.47	2.0
Reading [a]	7.68	3.71	1.4
Mathematics	7.83	4.11	1.4
Social Studies	7.76	4.50	1.4
Key Math Geometry			
Patterning	11.81	2.74	1.7
Reading	10.81	3.31	1.5
Mathematics	10.60	3.45	1.4
Social Studies	11.10	2.46	1.5
Key Math Multiplication			
Patterning	1.03	1.28	2.4
Reading	.42	1.29	2.0
Mathematics	.77	1.33	2.3
Social Studies	.59	1.18	2.1
Key Math Applied Problems			
Patterning	8.90	3.29	2.0

Reading[a]	7.16	3.41	1.5
Mathematics	8.03	3.59	1.7
Social Studies[a]	7.07	2.99	1.5

Note. Superscripts denote p <. 05 for a priori independent comparisons with Patterning[a]