DOING MORE THAN COMMON CORE MATHEMATICS IN KINDERGARTEN, FIRST AND SECOND GRADES

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Abstract: The Common Core Standards for mathematics, which outline what students should master at each grade level, are supposedly based on developing brain research. Assuming that the brains of East Asian and American children do not differ, the higher levels of mathematical achievement in the former suggest that the Standards underestimate the mathematical capacities of American students. To test this hypothesis, an accelerated pilot curriculum (Only the NUMBERS count©) using the explicit base-10 Asian count was introduced in a public grammar school. Longitudinal analysis of student performance both on computerized district-wide tests reported in this paper, and on individual one-on-one tests reported by Stokes (2015), showed students scoring above average, and exceeding Common Core requirements. Revisions to both Standards and curricula are discussed.

Keywords: Common Core, acceleration, mathematics, kindergarten, first grade, second grade

INTRODUCTION

The Standards Problem

The present study presents evidence that early grade level mathematical standards prescribed by the Common Core underestimate the potential of early elementary school-aged children, despite the claim that these standards are based on research regarding the developing brain.

As a set of learning trajectories set for each grade level, these standards are meant to be the hallmark of what educators should expect their students to master in a year's time (Clements, Baroody, & Sarama, 2013; Faulkner, 2013.; Schifter, 2012.; Wurman & Wilson, 2011). However, it is perplexing that, while they possess the same neuroanatomy as American students, children in several East Asian countries tend to perform significantly higher in numerical tasks than do their peers from the United States (Ginsburg, Choi, Lopez, Netley, & Chi, 1997; Stevenson, Chen, & Lee, 1993). We use the word "tend" because Stokes (2014a) reported that, exposed to a pilot curriculum using an explicit base-10 count, American kindergarteners both performed as well as their Chinese age mates (Siegler & Mu, 2008) on number line estimation, and at the level expected of first graders on place-value, addition, and subtraction.

Underestimating the cognitive ability of American grade school children could prove quite detrimental in the long-run. As with language learning, effectively gaining an understanding of mathematics is more likely to be successful when the brain is very plastic (Kaufmann & Dowker, 2009; Menon, 2010; Nelson, 2000). An additional consideration is extensive evidence that early mathematical achievement is predictive of later (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Bodovski & Farcas, 2007; Classens, Duncan, & Engel, 2008; Jordan, Kaplan, Ramineni, & Locuniak, 2009; Romano, Babchishin, Pagani, & Kohen, 2010). By delaying the introduction of topics and tasks that could be mastered earlier, the Common Core may be making mathematics education less rather than more efficient and effective.

The Classroom Problem

Another problem with the Common Core is that it doesn't change what happens in the classroom (Kilpatrick, 2011). While it mandates trajectories, it does not standardize curricula.

As taught in most American classrooms, math curricula are materially, but not mathematically, complex. Different activities (e.g., reading a story, filling in a worksheet, making groups with tiles) done with different materials (e.g., counters, straws, cube-trains) are not equivalent to developing different strategies for solving a type of problem. Multiple manipulatives are themselves a problem. Presented with 5 oranges and 5 apples, young children will focus on the things (the apples and oranges) that are counted rather than on the numbers (the 5s) or the operation (5 + 5) that combines them to make a higher number (10). They will not understand that numbers are combinations of other numbers, or why 10 is an even number. In short, they will not learn to think mathematically (Clements, 1999).

The more general problem is that — like the Standards themselves — current curricula promote split rather than deliberate practice (Stokes, 2013). In split practice, students switch (often) between problem types: a little addition, a bit of measurement, a snippet of subtraction. In contrast, deliberate practice is focused, continuous, and incremental: students switch between strategies[1] rather than between problem types or materials.

The Solution in Question

The solution in question is a pilot curriculum that reduces math to what really counts: numbers, symbols, and patterns.

The curriculum, called *Only the NUMBERS count,*© simplifies the teaching and learning of mathematics in several ways. First, it condenses the number of concepts taught. For example, place-value is built into the explicit base-10 count that children learn in kindergarten (Stokes, 2014a). The count is based on that used in China, Japan, and Korea, countries with considerably higher grade-school mathematics achievement (Fuson, 1990). Table 1 shows the count from 1 through 29, which is called "two-ten-nine."

Take the number 14. Calling that number "fourteen" obscures the value of each digit. Calling it "ten-four" makes the value of each digit's place plain. The count does more than that. It also makes the reiterative pattern in which numbers combine to form other numbers plain and,

[1] For a discussion of multiple addition (and other) strategies used by young children, see Siegler & Jenkins (1989).

importantly, it emphasizes that 10 is not just 10 ones: it is itself, a unit which appears in every number above 10. How this simplifies counting/calculating was shown in a classic experiment in which children were given blocks representing tens and blocks representing ones. Asked to put together a set of blocks that equaled 42, American children counted out 42 ones blocks. The far more efficient set counted out by East Asian children was 4 tens blocks and 2 ones blocks (Miura & Okamoto, 2003). Their combination of tens and ones showed that these children were thinking in base-10. Thinking in base-10 was a goal of the pilot curriculum.

Table 1: *Explicit base-10 count*

Ones		*Tens*		Two-*tens*	
		10	*ten*	20	two-*ten*
1	one	11	*ten*-one	21	two-*ten*-one
2	two	12	*ten*-two	22	two-*ten*-two
3	three	13	*ten*-three	23	two-*ten*-three
4	four	14	*ten*-four	24	two-*ten*-four
5	five	15	*ten*-five	25	two-*ten*-five
6	six	16	*ten*-six	26	two-*ten*-six
7	seven	17	*ten*-seven	27	two-*ten*-seven
8	eight	18	*ten*-eight	28	two-*ten*-eight
9	nine	19	*ten*-nine	29	two-*ten*-nine

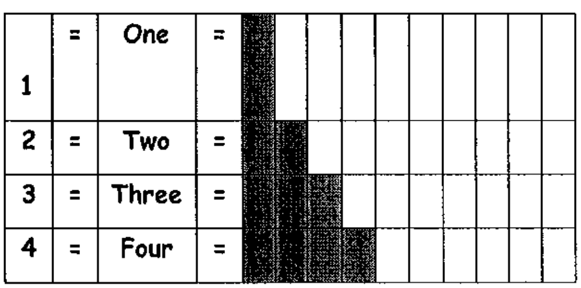

Figure 1. *Count-and-Combine Chart 1 to 4*

A second simplification was designed to establish equivalence between number symbols, number names, and number of things. Only one manipulative was used in kindergarten and first grade, a Count-and-Combine Chart[2] that represented numbers, number names and symbols. The manipulative, much like the abacus, was meant to represent *only* numbers, symbols, and their relationships (Stokes, 2014a, 2014b).

Figure 1 shows the first four rows of the 1 to 10 chart.

[2] The teachers made their own charts from foam core, velcro, and poster board.

All parts of the chart were moveable, meant to be combined and re-combined in multiple ways. Children had bags of what they called "blocks" (squares made of poster board representing numbers, symbols, ones, and tens) at their tables. They used their "blocks" to practice mathematical patterns. For example, using one, two, or three plus signs, there are seven possible addition combinations for 4. Figure 2 shows two of these combinations.

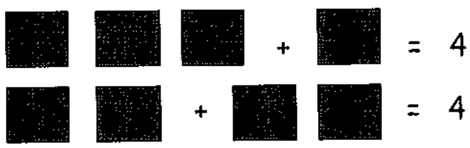

Figure 2. *Combinations for four*

A third simplification, the Multi-Purpose Chart (a significantly modified version of the Chinese multiplication table) made the patterned relationships between multiplication, division and fractions plain. The patterning allowed the three operations to be taught simultaneously.[3]

Reported Results

Children taking part in the pilot curriculum were tested individually at the start and end of kindergarten (Stokes, 2014a) and first grade (Stokes, 2014b), and at the end of second grade (Stokes, 2015). The results support the hypothesis that American elementary school children are far more capable than Common Core assumes.

Kindergarteners, taught with *Only the NUMBERS count©*, mastered double-digit addition and subtraction, place value, and number line estimation. Their achievement exceeds the expectations of Common Core mathematics standards for kindergarten. In fact, it meets the level of mastery required for first, and for some students, second grade. In contrast, students taught with a generic American curriculum program (*EnvisionMath*) did not master concepts above those laid out by the Common Core learning trajectories for their grade level (Stokes, 2014a).

First graders who were taught with *EnvisionMath* in kindergarten and introduced to *Only the NUMBERS count©* in first grade also exceeded the levels of mastery required by the Common Core Standards for first grade, and met several standards for third grade, as did students who had *Only the NUMBERS count©* in both kindergarten and first grade (Stokes, 2014b).

[3] For a complete discussion of the chart, see Stokes (2015).

A small project using a modified Chinese multiplication table showed that first graders (selected for their math ability) were capable of mastering multiplication. The results led to the Multi-Purpose Chart being introduced, not in first, but in second grade to all students. Post-testing at the end of second grade again showed that students were doing more than required by Common Core, which specified multiplication, division and fractions as skills to be acquired in third grade. Notably, all of these data were collected in a public school in New Jersey, with mixed socioeconomic status and ethnicities.

The Research Question

We had a single question: would a longitudinal analysis of independent test data also support our hypothesis, i.e., that American children are capable of doing more than required by the Common Core Standards.

METHOD

Participants

Students from three classrooms over three years (kindergarten, first grade, and second grade) at a suburban public school in New Jersey served as the test group for this study. Children were assigned to three classrooms each year by gender (to equalize the number of boys and girls) and not by ability. All students were taught mathematics using solely *Only the NUMBERS count©* during kindergarten, first grade, and second grade.[4] Students who joined the school after the start of kindergarten or left for another school during the course of the study were omitted. Student performance on state testing, *Early Numeracy* (in kindergarten) and *Renaissance Star* (in first and second grade) were recorded over time.

Students. There were 15 female and 17 male students. Of these, 10 were White, 8 were Hispanic, 6 were Multi-racial, 4 were Asian, and 4 were African-American. Three were economically disadvantaged (qualified for free lunch). All were proficient in English, of these 10 were bi-lingual, speaking a second language at home. Mean age at end of 2nd grade was 8 years, 1 month (97 months). Range was 7 years, 9 months (93 months) to 8 years, 8 months (104 months).

Teachers. All kindergarten teachers had at least one year's prior experience with the pilot curriculum. Two first and all three second grade teachers were using the curriculum for the first time when these children were in their classes. One first grade teacher helped develop lesson plans for K and first grade, so this was her second year using the curriculum with a first grade class.

Measures

Scores on state/district tests from September and May in kindergarten/first grade and September and April in second grade were analyzed. In kindergarten, the test used was called *Early Numeracy*. This examination assesses young students' basic understanding of concepts like oral counting, number identification, quantity discrimination (identifying a larger/smaller number), and missing number (e.g. in a series: 14, 15, __). Early numeracy is scored from 1-100. In first and second grade, the students were evaluated using *Renaissance Star* math testing. Tests are scored in X.Y format with X being the grade level and Y

[4] Of the 35 students in this group, 3 were excluded from the current analysis due to missing data points.

being the month. For example, a score of 1.3 means that a student is at a first grade, third month mastery level, in respect to the Common Core Standards. Percentiles were also reported for the *Renaissance Star* tests, with the fiftieth percentile representing the average for a given test in the state of New Jersey.

Observational data were collected in the classroom settings once each week during the school year. The progress of individual students, as well as entire classes, was noted.

RESULTS

Class Data

Table 2 presents means and standard deviations for test taken at the start and near the end of the school year. There are several things to notice. First, between September and May, average Kindergarten scores increased by 14 points. Second, at the start of both 1^{st} and 2^{nd} grade, means were approximately 2 months above expectations (year/month in which test was taken); by the end, means were 4 months above in 1^{st} grade, and 7 months above in 2^{nd}. Third, all percentiles in 1^{st} and 2^{nd} grades were between 12 and 24 percentage points higher than the state average (50^{th} percentile).

Table 2. *Scores for Kindergarten, First, and Second Grade.*

Test Type	Grade	Date (Year/Month)	Score Mean	Score SD	Percentile Mean	Percentile SD
Early Numeracy	K	Sept. 12	67.57	17.03	-	
		May 13	81.37	15.49	-	
Renaissance Star	1^{st}	1.1	1.37	.52	72.91	17.40
		1.9	2.34	.53	70.04	17.76
	2^{nd}	2.1	2.32	.68	62.38	21.92
		2.8	**3.54**	.76	**74.81**	17.16

We also examined the distribution of scores at the end of 2^{nd} grade. Table 3 shows the breakdown. 29 students scored above grade level, only 3 scored below. We can further collapse the distribution into three groups: one with 7 members scoring between 2.0 and 2.9; a second with 16 scoring between 3.0 and 3.9; and a third with 9 members scoring between 4.0 and 5.0.

Table 3. *Renaissance Star scores for eighth month of 2^{nd} grade*

Level	Distribution
Grade level	2. 9
Below grade level (3)	1 at 2.0 2 at 2.7
Above grade level (29)	***4 at 2.9*** ***16 between 3.0 and 3.9*** 10 between 3.0 and 3.4 6 between 3.5 and 3.9 ***8 between 4 and 4.9*** 4 between 4 and 4.4 4 between 4.5 and 4.9 ***1 at 5.0***

Individual Data

Finally, to sample individual learning trajectories, we compared longitudinal data for one student in each of three groups corresponding roughly to the collapsed distribution.

The first was made up of students selected by their teachers to attend an enrichment math class once a week during the spring in first grade. This group, like their representative (labeled Honors) in Figure 3, scored very highly on state examinations from kindergarten through second grade. The second group, like their representative (labeled Average), was made up of members indicative of the average student participating in the study. Their performance on state examinations was constantly at or above average. Finally, there was a group of students that initially struggled in math. Like their representative (labeled Low) these students initially scored below average, but improved enough to become close to, at (end of 1st, start of 2nd grades) or even above (end of 2nd grade) month/year expectations.

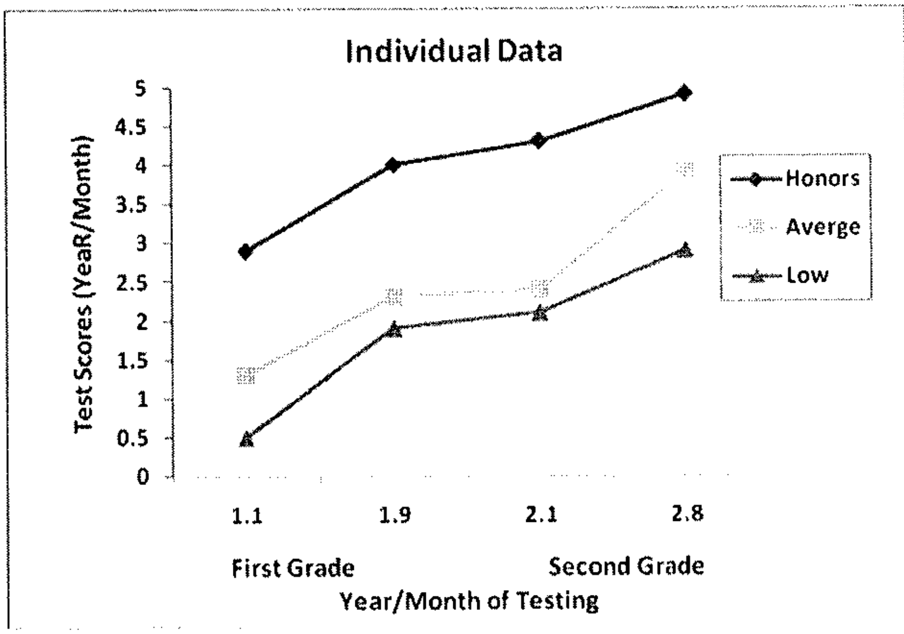

Figure 3. *Individual Data*

There are two things to notice in Figure 3. One, the three slopes show similar upward trajectories: from the start of 1st to the end of 2nd grade, all scores increased *2 years or more*. Two, while the Honors student consistently outperformed the others, the gaps between Honors/Average, and between Honors/Low narrowed by the end of second grade.

DISCUSSION

Limitations

The major limitation in the current study is the lack of a comparison group. When *Only the NUMBERS count*© was introduced in kindergarten and first grade, it was compared to classes taught with a standard curriculum. The testing took place prior to the current group of students entering kindergarten. As a result, their teachers used *Only the NUMBERS count*© in both kindergarten and first grade. It did not seem ethical to withhold the continuity or, more importantly, the curriculum's proven effectiveness from some of these students, while providing it to others in second grade.

Confirmations and Implications

These data confirm what individual one-on-one testing at the end of K, 1st and 2nd grades (Stokes, 2014a, 2014b, 2015) has already shown: students taught with *Only the NUMBERS count*© from K through 2nd grade perform better than expected at their grade levels, which means they are doing more than expected by Common Core Standards for math.

The group as a whole entered first grade with scores slightly above grade level (1.37), but by the end of second grade, performed like students in the middle of third grade (3.54). By the end of second grade, honors level students performed like students in 4th or 5th grade; eight scores were between 4.0 and 4.9; one was 5.0. At the other end of the achievement spectrum, only three children performed below grade level; two of these scores were 2.7 (1 month below). If children of different abilities — low, average and honors — can do more than expected by the Common Core Standards for math, then the Standards clearly underestimate what young children are capable of learning. Topics and tasks that young children could master earlier are introduced later.[5]

There are two related implications. One, as suggested at the start of this paper, is that the Standards could be making early mathematics education less rather than more efficient and effective. The other is that current curriculum, designed to meet the Standards, are doing the same.

Suggestions

Our suggestions are also twofold and also related. The first is that the Common Core Standards be revised to match the achievements of East Asian children, whose brains (as already noted) are not anatomically or neutrally different from American students. Recognizing what the developing brain is capable of, and taking advantage of neural plasticity is critical because (as discussed earlier) early achievement in math is predictive of later achievement (Romano et al., 2010).

The second is that American curricula be revised to focus (as both East Asian curricula and *Only the NUMBERS count©* do) on numbers, symbols, and patterns. A goal for both Standards and curricula is having American children, like their Asian age-mates, *think mathematically*.[6] The current results, along with prior data (Stokes, 2014a, 2014b, 2015), show that they can. If they can, then they should.

Conclusion

This paper asked a single question: will independent test data corroborate one-and-one test results (Stokes, 2014a, 2014b, 2015) in supporting our hypothesis, e.g., that American children can do more in mathematics than expected by the Common Core Standards. The answer, provided by *Early Numeracy* and *Renaissance Star* computerized tests is yes.

Our conclusion is straightforward. Since our children can do more, then we must expect more — both from the Core and from curricula. *Only the NUMBERS count©* supports this conclusion in two ways. It shows that higher expectations can be set, and it demonstrates one way in which they can be met.

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[5] For example, multiplication, division and fractions in 2nd rather than 3rd grade.

[6] One place to start is introducing an explicit base-10 count in kindergarten. *Thinking in base-10* has been shown to solve the place-value problem and to facilitate master y of addition and subtraction in kindergarten (Stokes, 2014a).

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