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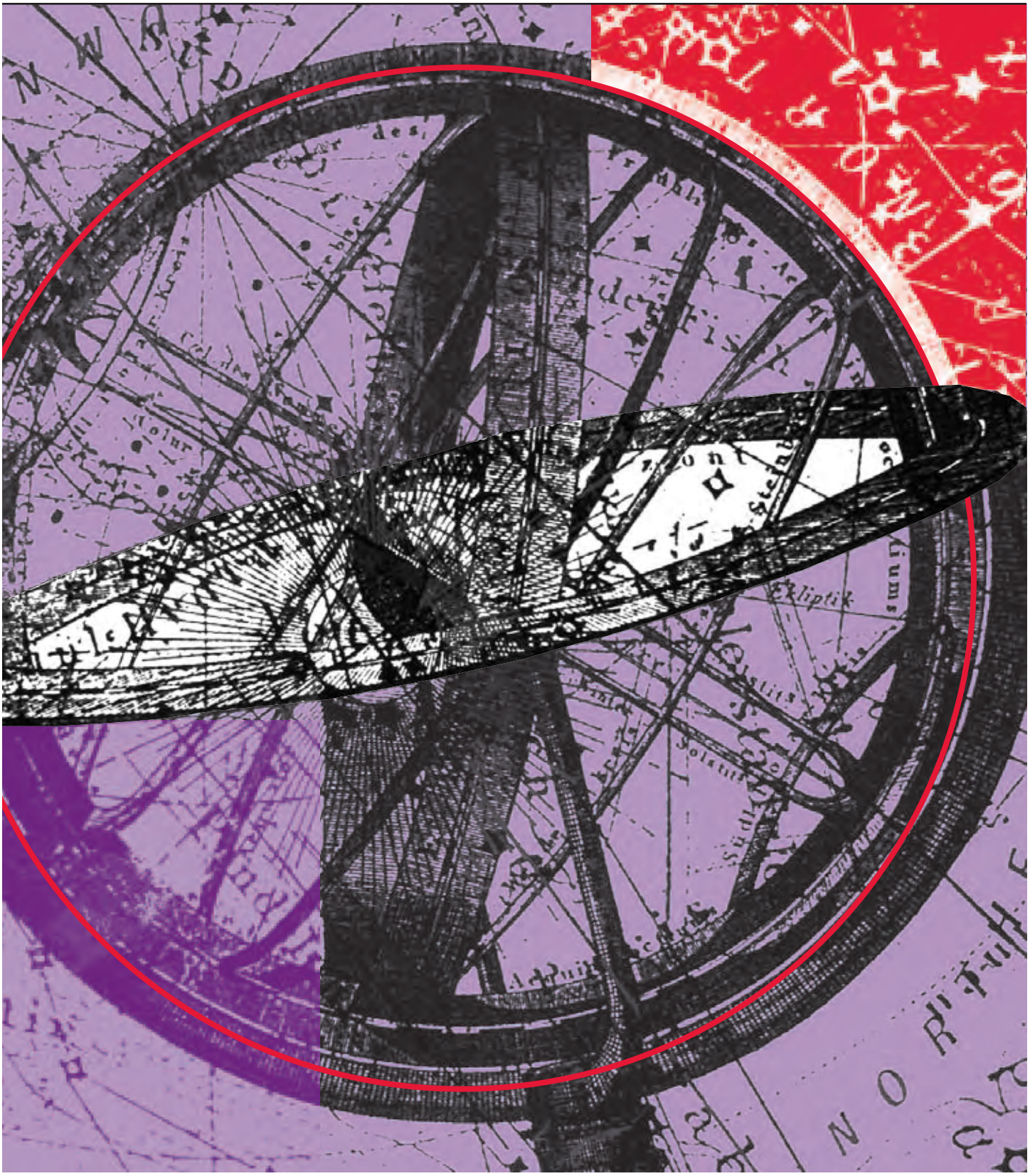

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What is the Focus and Emphasis on Calculators in State-Level K-8 Mathematics Curriculum Standards Documents?

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The availability of calculators has influenced mathematics instruction, assessments, and textbooks since they were first introduced into K-8 mathematics classrooms 30 years ago. During that time, there has been a steady line of research (e.g., Hembree & Dessart, 1986; 1992; Shumway, White, Wheatley, Reys, Coburn, & Schoen, 1981; Suydam, 1979) and numerous recommendations from professional organizations (National Council of Teachers of Mathematics, 1989, 2000, 2005; National Research Council, 1990; National Council of Supervisors of Mathematics, 1988) supporting the use of calculators. Furthermore, 35 states make references to calculators within state curriculum documents and 40 states allow the use of calculators on some portions of state mathematics assessments. Many current mathematics textbooks include mathematical tasks designed for use of calculators. Even though the use of calculators has been encouraged for some time, their use in elementary and middle school mathematics classrooms remains controversial. For example, authors of a recent Thomas B. Fordham Foundation report, *The State of State Math Standards* (2005) conclude: "One of the most debilitating trends in current state math standards is their excessive emphasis on calculators." (p. 14)

This assertion in the Fordham report encouraged us to conduct our own analysis of official state mathematics curriculum standards documents so that we might understand and describe the extent to which states support use of calculators in elementary and middle school mathematics classes. In particular, we examined messages about calculators conveyed within these documents to school administrators and classroom teachers. In this paper, we report the findings from our analysis, identify contradictions with the Fordham report, and discuss leadership efforts needed to support teachers in their use of calculators.

State-Level Mathematics Curriculum Standards Documents

The federal *No Child Left Behind* act of 2001 prompted a wave of state-level curriculum articulation with specific attention to decisions about grade-by-grade learning expectations in mathematics. In fact, nearly three-fourths of the states have published new curriculum standards since 2001 (Reys, et al, 2005). While some of these documents are intended to be "models" for local school districts to utilize in shaping their own curriculum specifications, others are mandatory, specifying the mathematics all students within the state are expected to learn at particular grades. In addition, these curriculum standards serve as guidelines for shaping annual statewide grade-level assessments. As a collection, the new state-level mathematics curriculum standards represent the mathematics students in the U.S. are expected to learn.

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TABLE 1: *Name and publication date of state-level mathematics curriculum documents (42) analyzed for this study (as identified by a search of state education department websites as of May 2005).*

State	Document*	Year Published
AL	Alabama Course of Study: Mathematics	2003
AK	Grade Level Expectations	2004
AR	Arkansas Mathematics Curriculum Frameworks K-12	2004
AZ	Grade Level Expectations	2003
CA	Mathematics Framework for California Public Schools: K-12	2005
CO	Grade Level Expectations (Examples)	2000
DoDEA	Mathematics Curriculum Content Standards	2004
DC	Standards for Teaching and Learning	2002
FL	Sunshine State Standards	1996
GA	Georgia Performance Standards	2004
HI	Framework and Instructional Guides–Grade Level Performance Indicators	2004
ID	Idaho Mathematics Achievement Standards	2005
IN	Indiana's Academic Standards for Mathematics	2000
KS	Kansas Curricular Standards for Mathematics	2003
LA	Grade Level Expectations	2004
MD	Maryland Voluntary State Curriculum	2004
ME	Grade Level Expectations	2004
MI	Michigan Grade Level Content Expectations (GLCE)	2004
MN	Minnesota Academic Standards–Mathematics	2003
MO	Mathematics Grade Level Expectations	2004
MS	Mississippi Mathematics Framework 2000	1999
NC	Mathematics Standard Course of Study and Grade Level Competencies	2003
ND	Mathematics Content Standards	2005
NH*	Local Grade Level Expectations (K-8) (with RI)	2004
NJ	New Jersey Core Curriculum Content Standards for Mathematics	2002
NM	Mathematics Content Standards, Benchmarks, and Performance Standards	2002
NV	Nevada Content & Performance Standards	2003
NY	New York Learning Standards for Mathematics	2005
OK	Priority Academic Student Skills	2002
OH	Academic Content Standards K-12 Mathematics	2001
OR	Oregon Grade Level Standards and K-2 Foundations	2002
RI*	Local Mathematics Grade Level Expectations (with NH)	2004
SC	South Carolina Mathematics Curriculum Standards 2000	2001
SD	South Dakota Revised Mathematics Content Standards	2004
TN	Mathematics Curriculum Standards	2001
TX	Texas Essential Knowledge and Skills for Mathematics	1998
UT	Mathematics Core Curriculum	2003
VA	Virginia Mathematics Standards of Learning Curriculum Framework	2002
VT	Grade Expectations for Vermont's Framework of Standards and Learning Opportunities	2004
WA	Mathematics K-10 Grade Level Expectations: A New Level of Specificity	2004
WV	Mathematics Content Standards and Objectives for West Virginia Schools	2003
WY	Wyoming Mathematics Content and Performance Standards	2003

* Links to each document are available at: http://mathcurriuclumcenter.org/statestandards

** New Hampshire and Rhode Island share a common document.

School administrators, teachers, and curriculum developers are carefully considering the content in the state curriculum standards, including the grade-by-grade learning expectations, as they design, teach, and monitor mathematics learning. Therefore, these documents and the messages they convey are likely to impact, in important ways, what is included in future mathematics textbooks and how mathematics is taught. Our analysis of the state curriculum documents was guided by the following questions:

1. To what extent do state-level K-8 mathematics curriculum standards documents refer to the use of calculators? How does the extent of use differ across grade levels?
2. What expected roles of calculators are articulated in state-level K-8 mathematics curriculum standards documents? How do the expected roles differ across grade levels?
3. What general messages are conveyed regarding calculator use within state-level mathematics curriculum documents at grades K-8?

Methods

We began by collecting the most recent mathematics curriculum standards documents from all 50 states as well as the District of Columbia (DC) and the Department of Defense Educational Agency (DoDEA) (see http://mathed-db.missouri.edu/states.php for links to the documents). We identified documents that focused on elementary and middle grades and specified grade-by-grade learning expectations (LE). At the time of our analysis several states did not specify grade-by-grade LEs in mathematics and some states were in the process of finalizing draft documents, therefore we did not include these documents in the analysis. Our analysis included a review of 42 curriculum documents (see Table 1) which convey elementary and middle school mathematics grade-level LEs.

We conducted word searches for "calculator" and "technology" in the general introductory material of the curriculum documents as well as in the specific LEs within K-8 grade-level sections of the documents. We then compiled all of these statements and used that compilation as the data source for our analysis. For the specific grade-level LEs, the three authors individually coded each LE according to the role of the calculator and then met together to discuss and reach consensus on the specific code(s) for each LE.

Table 2 summarizes state documents that include messages related to calculators/technology within the introductory material and/or within specific LEs. As noted, 20 state documents include a discussion of the role of calculators/technology within the introductory material and 32 state documents include the terms calculator and/or technology within a subset of learning expectations. Documents from six states and the Department of Defense include no use of either term in the introductory narrative or within the set of LEs. The District of Columbia document includes "technology integration standards" as a separate section of

TABLE 2: *Summary of states with curriculum standards documents that include the terms "calculator" or "technology" in introductory material or within statements of specific learning expectations.*

		Terms "calculator" and/or "technology" used in introductory sections of document			
		YES		NO	
Terms "calculator" and/or "technology" used within learning expectations	YES	Arkansas Kansas Nevada North Dakota New Mexico Ohio Texas Virginia West Virginia	California Mississippi North Carolina New Jersey New York Oklahoma Utah Washington	Alaska Colorado Florida Hawaii Indiana Michigan Oregon Tennessee	Arizona District of Columbia Georgia Idaho Louisiana Minnesota South Carolina
	NO	Alabama South Dakota Wyoming Vermont		DoDEA Maine New Hampshire	Maryland Missouri Rhode Island
	Total	20		22	

the document. While some of the learning expectations within this section focused on mathematics, most were related to general proficiency with technology. Therefore, we choose not to include the District of Columbia document in the analysis.

Summary of Findings from Analysis of Introductory Narrative

As noted in Table 2, 20 state-level mathematics curriculum documents include statements regarding the role of calculators/technology within the introductory narrative. This material ranged in length from a single sentence to an entire chapter. For example, the *Kansas Curricular Standards for Mathematics* (2003) includes the following single statement in the introductory narrative related to calculators/technology:

> Technology will be a fundamental part of mathematics teaching and learning. (p. 6)

On the other hand, the California *Mathematics Framework* (2005) includes a full chapter summarizing a perspective and policy regarding calculators. The message within the California document regarding the role of calculators/technology is clearly more guarded and oppositional in nature than in other state documents. For example, unlike other state documents, there is a stated policy restricting use of calculators in grades K-5 indicating that:

> Extensive reliance on calculators runs counter to the goal of having students practice [computational and procedural skills]. More to the point, it is imperative that students in the early grades be given every opportunity to develop a facility with basic arithmetic skills without reliance on calculators. (p. 373)

Indeed, there is no mention of calculators/technology until grade 6 in the grade-level learning expectations within the California document. However, the policy regarding calculators/technology continues:

> It should not be assumed that caution on the use of calculators is incompatible with the explicit endorsement of their use when there is a clear reason for such an endorsement. Once students are ready to use calculators to their advantage, calculators can provide a very useful tool not only for solving problems in various contexts but also for broadening students' mathematical horizons. (p. 374)

A review of the other state documents reveals strong advocacy for use of calculators and technology to support student learning with caution regarding "appropriate" use of these tools. In general, calculators/technology are described as "tools" for supporting learning and carrying out computation within problem-solving settings. Teachers are charged with being responsible for making decisions about when calculators/technology are useful in reaching goals outlined in the state curriculum framework. Likewise, statements warn against over- or inappropriate use of calculators/technology. Examples of appropriate uses of calculators/technology are provided within the documents, often delineated by particular grade levels or grade bands, and include: exploring mathematical patterns, solving complex problems, and organizing or displaying data.

The most common messages within the introductory narrative sections of the documents along with illustrative examples are summarized in Table 3. These common messages include:

1. Appropriate use of calculators/technology is encouraged.
2. Calculators/technology are commonly used in the workplace and outside of school, therefore students should use these tools to solve problems.
3. Calculators/technology are tools for learning and teaching.
4. Calculators/technology can support increased understanding.
5. The existence of calculators/technology does not diminish the need for computational fluency.
6. Calculators/technology can support effective teaching.
7. Teachers are responsible for appropriate and effective use of calculators/technology.

Many of the common messages noted within the set of documents are captured in the following statements found in the introductory sections of the *Alabama Course of Study: Mathematics* (2003):

> Appropriate use of technology is essential for teaching and learning (p. 3).

> Technology enhances the mathematics curriculum in many ways, but is not intended to serve as a replacement for the teacher. The effective use of technology, however, does depend on the teacher. Teachers use technology in mathematics instruction to prepare students for an ever-changing world. The teacher makes

TABLE 3: ***Common messages regarding calculators within introductory documents.***

Message	Example
Appropriate use of calculators/technology is encouraged.	The Mississippi Department of Education strongly encourages the use of technology in all mathematics classrooms. The learning and teaching of mathematics can be greatly enhanced when quality instructional technology is appropriately used. (Mississippi Mathematics Framework, 2000, p. 9)
Calculators/technology are commonly used in the workplace and outside of school, therefore students should use these tools to solve problems.	Society needs individuals who have sound estimation skills and number and spatial sense, who are competent using and interpreting data, and who can use appropriate technology resources to solve problems and make informed decisions. These skills are essential if students are to become successful citizens, life-long learners, and competitive workers in a global market place. (Nevada Mathematics Standards, 2003, p. 3)
Calculators/technology are tools for learning and teaching.	Electronic technologies such as calculators and computers are essential tools for teaching, learning, and doing mathematics. They furnish visual images of mathematical ideas, facilitate organizing and analyzing data, and compute efficiently and accurately. They support investigation by students in every area of mathematics and allow students to focus on decision-making, reflection, reasoning, and problem solving. (New Mexico Mathematics Content Standards, Benchmarks and Performance Standards, 2002, p. 3)
Calculators/technology can support increased understanding.	Technology can be used by students to strengthen and extend their understanding of concepts, explore mathematical functions, engage in problem-solving activities, employ real world applications, and verify results of mathematical activities. When technology is combined with a student's understanding of underlying mathematical concepts, learning is enhanced. (Nevada Mathematics: Content Standards for Kindergarten and Grades 1 through 8 and 12 , 2003, p. 3)
The existence of calculators/technology does not diminish the need for computational fluency.	The incorporation of technology in instruction enables teachers to use problems containing actual numbers from existing situations rather than numbers to facilitate hand calculations. However, students must also understand quantitative concepts and relationships and demonstrate a proficiency in basic computation using calculators as an aid rather than a crutch. (Wyoming Mathematics Content and Performance Standards, 2003, p. 1-2)
Calculators/technology can support effective teaching.	Technology also supports effective mathematics teaching and can dramatically increase the possibilities for engaging students with challenging content using visualization, simulation, graphing, and advanced computing. (New Mexico Mathematics Content Standards, Benchmarks and Performance Standards, 2002, p. 3)
Teachers are responsible for appropriate and effective use of calculators/technology.	West Virginia teachers are responsible for integrating technology appropriately in the students learning environment. Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. (Mathematics Content Standards and Objectives for West Virginia Schools, 2003, p. 8)

instructional decisions about worthwhile investigative tasks that take advantage of technological aids. Technology influences the mathematics taught by providing exploratory opportunities and visual displays that would be tedious to generate by hand. Technology should be used to foster, rather than replace, the understanding of basic mathematical concepts. The use of appropriate technological tools provides support for all students to learn mathematics. Technology can be used by students and teachers to assess the understanding of meaningful mathematical concepts and to investigate more complex problems. (p. 6)

In summary, 20 state documents note the potential of calculators/technology tools to support teaching and learning. We did not find explicit statements regarding calculators/technology within the introductory material in the other 22 state documents reviewed for this analysis. While some of these documents include references to calculators/technology within the set of learning expectations, others do not. In the next section we summarize the analysis of the specific learning expectations which reference calculators/technology.

TABLE 4: *Number of calculator/technology learning expectations per grade by state (shaded rows indicate state documents that do not reference calculators or technology within the statements of learning expectations).*

State	K	Gr. 1	Gr. 2	Total Gr. K-2	Gr. 3	Gr. 4	Gr. 5	Total Gr. 3-5	Gr. 6	Gr. 7	Gr. 8	Total Gr. 6-8	Total Gr. K-8	Mean of State
AL														
AK					3	2	2	**7**	3	2	3	**8**	**15**	**1.67**
AR	2	2	2	**6**	4	5	4	**13**	6	13	18	**37**	**56**	**6.22**
AZ									1	1	1	**3**	**3**	**0.33**
CA									1			**1**	**1**	**0.11**
CO		1	1	**2**	1	1	3	**5**	3	3	3	**9**	**16**	**1.78**
DODEA														
DC*														
FL		3	5	**8**	2	2	2	**6**	3	2	3	**8**	**22**	**2.44**
GA		1	1	**2**	1	2	2	**5**	2	2	3	**7**	**14**	**1.56**
HI						1	1	**2**					**2**	**0.22**
ID							1	**1**	1			**1**	**2**	**0.22**
IN									2	1	4	**7**	**7**	**0.78**
KS		1	1	**2**	2	2	1	**5**	3	3	4	**10**	**17**	**1.89**
LA					1	1		**2**			1	**1**	**3**	**0.33**
MD														
ME														
MI									1	1	1	**3**	**3**	**0.33**
MN									3	3	4	**10**	**10**	**1.11**
MO														
MS	1	1		**2**	3	1	4	**8**	5			**5**	**15**	**1.67**
NC					1	3	1	**5**	1	1	1	**3**	**8**	**0.89**
ND					1			**1**			1	**1**	**2**	**0.22**
NH/RI														
NM			1	**1**						1	4	**5**	**6**	**0.67**
NJ					4	4	3	**11**	4	5	5	**14**	**25**	**2.78**
NV	1	1	1	**3**	1	1	3	**5**	3	4	7	**14**	**22**	**2.44**
NY							3	**3**	1	3	1	**5**	**8**	**0.89**
OK										2		**2**	**2**	**0.22**
OH					1	1	1	**3**	1	2	2	**5**	**8**	**0.89**
OR											1	**1**	**1**	**0.11**
SC			3	**3**	2	2	3	**7**	1	1	1	**3**	**13**	**1.44**
SD														
TN		1	1	**2**		1	1	**2**	2	2	2	**6**	**10**	**1.11**
TX	3	3	3	**9**	3	2	4	**9**	1	2	4	**7**	**25**	**2.78**
UT			1	**1**	1	1	3	**5**	2			**2**	**8**	**0.89**
VA	1	4	2	**7**	1	7	5	**13**	3			**3**	**23**	**2.56**
VT														
WA		2	5	**7**	4	5	3	**12**	6	9	7	**22**	**41**	**4.56**
WV										3	5	**8**	**8**	**0.89**
WY														
Total LE	8	20	27	**55**	36	44	50	**130**	59	66	86	**211**	**396**	**396**
Mean per grade level	0.26	0.65	0.87	**0.59**	1.16	1.42	1.61	**1.40**	1.90	2.13	2.77	**2.27**	**12.77**	**1.42**

* The DC document includes "technology integration" LEs which span all content areas and include emphasis on learning *about* technology.

Summary of Findings from Analysis of Learning Expectations

Thirty-one state curriculum documents were reviewed for this analysis — all those that contained references to the term "calculator" or "technology" within the set of grade-by-grade LEs, excluding the District of Columbia document. The state documents differ in their use of terms — calculator and/or technology — within statements of grade-level learning expectations with no document defining either term. For example, the Arkansas document uses "technology" exclusively, never referencing the term "calculators." On the other hand, eight state documents (AZ, CA, HI, ID, MI, OK, UT, and VA) use the term "calculator," but not "technology." Most states use both terms although they do not describe how their use of the terms differs. For this analysis, we focused on statements that pertained to use of some form of calculator — four-function, scientific, or graphing calculator — rather than computers or computer software. In the remaining sections of this paper we use the term "calculator" in summarizing the data, regardless of the choice of terms used in particular state documents.

The 31 state documents include a total of about 14,600 statements of learning expectations for elementary and middle school for a mean of 52 LEs per grade per state document (see Reys, et al., 2006 for a more complete summary of the documents). A subset of learning expectations — all those that included the phrase "calculator" or "technology" were identified from this set. This set included a total of 451 LEs or about 3 percent of all LEs. Twenty-one of the 451 LEs indicated that calculators/technology should not be used. For example:

> *Multiply and divide, without a calculator, numbers containing up to three digits by numbers containing up to two digits, such as 347 / 83 or 4.91 x 9.2. (MN, Grade 6, 2003).*

> *Convert between any two representations of numbers (fractions, decimals, and percents) without the use of a calculator. (IN, Grade 6, 2000).*

In addition, 34 of the 451 LEs focused on computer technology (e.g., software) rather than calculators. For example:

> *Identify and draw lines of symmetry in geometric shapes (by hand or using technology). (IN, Grade 3, 2000)*

> *The student recognizes and investigates attributes of circles, squares, rectangles, triangles, and ellipses using concrete objects, drawings, and/or appropriate technology. (KS, Grade K, 2003)*

The remaining LEs (396) formed the basis for our review. See Table 4 for a summary of the number of LEs referencing calculators by state. As noted, the Arkansas and Washington documents include the largest number of LEs (56 and 41 respectively) and several states (CA, HI, ID, ND, OK, and OR) include only one or two LEs referencing calculators. The mean number of LEs referencing calculators in the 31 state documents is 12.8 per state (1.4 per grade), or a little less than 3% of the total number of LEs per grade (1.4/52). If the Arkansas and Washington state documents are excluded, the mean drops from 12.8 to 10.3 calculator/technology LEs per state document or a little over one per grade.

As shown in Table 4, the number of LEs referring to calculators is greater in the upper grades than the lower elementary grades. For example, the mean number of calculator LEs per grade at grades K-2 is 0.59, at grades 3-5 it is 1.40, and at grades 6-8 it is 2.27. As might be expected, the majority of calculator-related LEs (56%) are found within the Number and Operation strand of the state documents (see Table 5 for a summary by strand).

TABLE 5: ***Proportion of 396 LEs that reference calculators/technology by content strand.***

Strand	Percent of LEs; N=396
Number and Operation	56%
Algebra	18%
Data Analysis and Probability	10%
Geometry and Measurement	4%
Other (Process Strands such as problem solving, communication, and reasoning)	13%

In summary, ten of the 42 states represented in Table 4 have mathematics curriculum standards documents that contain no references to calculators within the set of grade-level LEs. Another 18 of 42 states include ten or fewer references to calculators within their document. With the exception of the Arkansas and Washington state documents, no state document includes more than 25 LEs that reference calculators across grades K-8. As noted, across all the documents, the largest concentration of references to calculators is at the middle grades level. In fact, 211 of the 396 (53%) calculator-related LEs identified are found at grades 6, 7, or 8.

In addition to identifying the number of LEs that reference calculators/technology, the analysis included a review of the intended role of the calculator within the LEs. Six

TABLE 6: ***Summary of coding scheme for specific grade-level learning expectations.***

Message		Example
Represent	Students use calculators/ technology to represent mathematical quantities and ideas including different notations and graphs. They also connect physical models to mathematical language.	Represent and solve problem situations that can be modeled by and solved using concepts of absolute value, exponents and square roots (for perfect squares) with and without appropriate technology. (AR, grade 7) Organizes, graphs and analyzes a set of real-world data using appropriate technology. (FL, grade 8)
Solve problems or equations	Students use calculators/technology to solve applied problems or equations.	Use calculator, manipulatives, or paper and pencil to solve addition or subtraction problems (WA, grade 2) Use technology, including calculators, to solve problems and verify solutions. (NV, grades 5-8)
Develop or demonstrate conceptual understanding	Students use calculators/technology to build conceptual knowledge of mathematical ideas and/or demonstrate understanding of these concepts.	Uses a calculator to explore addition, subtraction, and skip counting.(FL, grade 1) Understand the concept of the constant as the ratio of the circumference to the diameter of a circle. Develop and use the formulas for the circumference and area of a circle. Example: Measure the diameter and circumference of several circular objects. (Use string to find the circumference.) With a calculator, divide each circumference by its diameter. What do you notice about the results? (IN, grade 6)
Analyze	Students use calculators/ technology to compare, interpret, identify relationships, make predictions, interpret graphs, or make sense of data.	Read, interpret, select, construct, analyze, generate questions about, and draw inferences from displays of data. Calculators and computers used to record and process information. (NJ, grade 6) Uses technology, such as graphing calculators and computer spreadsheets, to analyze data and create graphs. (FL, grade 7)
Compute or estimate	Students use calculators/technology to compute or estimate.	Use a variety of strategies to multiply three-digit by three-digit numbers Note: Multiplication by anything greater than a three-digit multiplier/ multiplicand should be done using technology (NY, grade 5) Generating sequences by using calculators to repeatedly apply a formula (NJ, grades 7-8)
Describe, explain, justify, or reason	Students use calculators/technology to help them describe strategies, explain reasoning, or justify mathematical thinking.	Use technology, including calculators, to investigate, define, and describe quantitative relationships such as patterns and functions. (NV, grades 5-8) The student communicates his or her mathematical thinking by representing mathematical problems numerically, graphically, and/or symbolically or using appropriate vocabulary, symbols, or technology to explain, justify, and defend strategies and solutions. (AK, grade 7)

TABLE 7: *Role of calculator/technology as specified in learning expectations within state-level curriculum documents.*

Role of Calculator/Technology	Grade Band	No. of States	No. of LEs	Total LEs*	Percentage of Total LEs (N=396)
Solve problems or equations	K-2 3-5 6-8	6 15 21	16 46 68	130	33%
Represent	K-2 3-5 6-8	2 11 21	5 17 83	105	27%
Compute or estimate	K-2 3-5 6-8	2 13 15	3 31 45	79	20%
Develop or demonstrate conceptual understanding	K-2 3-5 6-8	6 8 11	19 19 26	64	16%
Describe, explain, justify, or reason	K-2 3-5 6-8	8 8 9	16 18 29	63	16%
Analyze	K-2 3-5 6-8	2 5 15	3 7 41	51	13%

* The number of LEs does not sum to 396 because some LEs were coded in multiple categories.

different categories were identified from multiple readings (see Table 6 for a list of categories, descriptions and example LEs).

Table 7 summarizes the number of LEs assigned to each coded role. About one-third of the LEs focus on solving applied problems or equations and most of these are in the upper grades. A little over a fourth of the set of LEs focus on using calculators/technology to represent, model or graph mathematical ideas or data.

Twenty percent of the LEs reference calculators/technology as a tool for computing or estimating. That is, 79 of the 396 LEs that include a reference to calculators/technology convey an intention that the tool will be used primarily for computation and most of these (45 of 79) are at grades 6-8. These data suggest that calculators/technology are infrequently encouraged solely as a computational tool.

The most prominent role for calculators/technology in grades K-2 is for developing or demonstrating conceptual understanding, in grades 3-5 for solving problems or equations, and in grades 6-8 for representing mathematics.

In addition, two other sets of LEs referred to calculators. However, the focus was not on using calculators but rather on judgments made prior to or after use of the tool. They include choosing an appropriate method of calculation and checking the reasonableness of calculated answers. Examples of LEs in each category include:

> Solve problems using the four operations with whole numbers, decimals, and fractions. Determine when it is appropriate to use estimation, mental math strategies, paper and pencil, or a calculator. (UT, grades 5, 6)

> Use estimation as a tool for judging the reasonableness of calculator, mental, and paper-and-pencil computations. (SC, grade 5)

Ninety-six of the 396 LEs focus on checking the reasonableness of a calculated answer and/or choosing an appropriate method to calculate. Table 8 summarizes the number of instances by grade band. As noted, use of calculators for either of these roles is more frequent in the upper elementary or middle school years.

TABLE 8. *Summary of learning expectations referring to choosing appropriate methods of calculation and checking reasonableness.*

Tools	Grade Band	No. of States	No. of LEs	Total LEs*	Percentage of Total LEs (N=396)
Choose appropriate method of calculation	K-2 3-5 6-8	4 15 13	8 36 34	78	20%
Determine the reasonableness of a calculated answer	K-2 3-5 6-8	2 4 4	2 9 7	18	5%

Discussion

As noted earlier, authors of a recent Fordham Foundation report, *The State of State Math Standards* (2005), indicate that attention to calculators is a "common problem" associated with state mathematics curriculum standards. They conclude:

> One of the most debilitating trends in current state math standards is their excessive emphasis on calculators. Most standards documents call upon students to use them starting in the elementary grades, often beginning with Kindergarten. (p. 14)

Our analysis of the state mathematics curriculum standards documents does not support the conclusion offered in the Fordham Foundation report. We found only five state documents that include any references to calculators in the LEs for Kindergarten. In fact, about one-fourth of the state documents include zero references to calculators in statements of LEs at any grade level. Another 43% (18 of 42 documents) include 10 or fewer references to calculators across the set of elementary and middle grades LEs.

A close examination of the LEs that reference calculators reveals that the majority suggest calculators as tools for solving problems and/or representing data rather than as a replacement for facility with paper/pencil computation. It is also worth noting that references to calculators are concentrated at the middle grades. We found no indication that states advocate reliance on calculators at the expense of efficient mental or written procedures.

Within the introductory material of state mathematics curriculum standards documents, common messages include emphasis on appropriate use of calculators — as tools for representing and visualizing mathematical ideas and for exploring mathematical patterns. Teachers are encouraged to be responsible and selective in use of calculators and base decisions on instructional goals. There is also a clear message that computational fluency remains an important goal for students and availability of calculators/technology does not diminish the importance of this goal. While some state documents include a clear statement of philosophy regarding calculators/technology within the introductory material of state standards documents, others do not. Such as statement can clarify and make explicit official state policy and entrust teachers and administrators with making instructional decisions aligned with the policy.

Overall, our analysis does not suggest an overemphasis on or debilitating trend regarding calculator use as the Fordham Report indicates. We do concur with the authors of the Fordham Foundation report that, "with proper restriction and guidance, calculators can play a positive role in school mathematics . . ." (p. 15). We believe that additional guidance would be useful to teachers and administrators regarding the appropriate role of calculators/technology at particular grade levels.

Mathematics leaders need to develop forums and structures that support teachers as they interpret state curriculum standards, specifically regarding how to utilize the potential of the calculator as a tool to enhance mathematics teaching and learning. A recent national survey of K-8 mathematics teachers identified use of technology in mathematics instruction as their greatest professional development need (Weiss, Banilower, McMahon, & Smith, 2001). As leaders begin to develop discussion forums and professional development opportunities related to state learning expectations and standards, calculator use should be specifically addressed. For example, teachers may need:

- Examples of mathematical tasks or lessons that address specific grade-level expectations.
- Observations of effective instruction in classrooms or through the use of videos to provide images that convey the meanings of the calculator learning expectations.
- Resources such as calculators themselves or the corresponding materials that support their use.
- Help regarding discussions with parents about the purpose of calculator use.

Additionally, leaders should continue to take a proactive stance as they work to eliminate ineffective uses of calculators and provide evidence to dispel myths related to calculators.

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