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Mathematics Content in Early Childhood Classroom Libraries: Alignment with Common Core Mathematics Standards

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Abstract
In this study, researchers examined the math-related expository books found in 23 first-grade classroom libraries to determine specific mathematical concepts related to counting and cardinality and operations and algebraic thinking addressed in each. In addition, they examined how these concepts aligned with the first-grade Common Core State Standards for Mathematics. Results indicate that most of these texts contained concepts related to counting and cardinality but were better aligned with kindergarten standards than the first-grade standards. Very few of the books contained content related to operations and algebraic thinking and again, those that did focused on content more appropriate for kindergarten students.

Keywords Math trade books · Classroom libraries · Early childhood classroom libraries · Math book evaluation tool · Picturebooks

Introduction

Teaching mathematics with children's literature appears to be an enduring trend. Children's books, also known as trade books, have many features that contribute to their appeal for using them in math instruction. These features include inviting illustrations, conversational writing style, strong authorial voice, interesting and engaging language, and the potential for being current (Young et al., 2020).

Monroe et al. (2018) sought to determine if there was a research base for the practice. They identified 21 research studies that examined using trade books in mathematics instruction; trade books are found in libraries and bookstores rather than in the educational market. In examining the results of the studies, Monroe et al. found 15 distinct benefits for incorporating children's literature in mathematics instruction including (p. 18):

- Increases mathematics achievement (Leonard et al., 2014; Roberts & Stylianides, 2012; Thomas & Feng, 2015);
- Builds interest in and positive attitude toward mathematics (Keat & Wilburne, 2009; Leonard et al., 2014);
- Engages students in mathematical discourse (Elia et al., 2010; van den Heuvel-Panhuizen, & van den Boogaard, 2008);
- Deepens conceptual understanding (Roberts & Stylianides, 2012; Wilburne et al., 2007);
- Provides a meaningful context for learning mathematics (Adams & Lowery, 2007; Leonard et al., 2014);
- Improves problem solving abilities (Adams & Lowery, 2007; Keat & Wilburne, 2009)
- Increases mathematics vocabulary (Capraro & Capraro, 2006)
- Enhances justification and reasoning (Capraro & Capraro, 2006; Roberts & Stylianides, 2012);
- Enhances numeracy learning (Roberts & Stylianides, 2012; Young-Loveridge, 2004);
- Increases mathematical confidence (Keat & Wilburne, 2009; Thomas & Feng, 2015); and
- Integrates mathematical content across subject areas (Mink & Fraeser, 2005; Thomas & Feng, 2015).

Monroe et al. found that "of particular note is that no negative findings were identified" (p.19).

Not all trade books with mathematical content in the classroom are used for instruction. Teachers are encouraged

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to have classroom libraries to give students increased access to books for self-selected reading and browsing (Young et al., 2020). Recommendations are that these classroom collections include a balance of fiction and nonfiction (Young & Moss, 2006) and that nonfiction books represent both the content areas taught and general student interests (Dreher & Kletzien, 2015). Moreover, Dreher and Kletzien suggest that two-thirds of the nonfiction books be expository books which would be 33% of the total number of books in the classroom library.

Categories and Terms

Several terms are used to describe informational texts. The Common Core State Standards (CCSS) define them as "all factual, research-based nonfiction … as well as reference books, instructions, forms, maps, persuasive essays, and so forth" (National Governors Association Center for Best Practices & Council of Chief State School Superintendents, 2010a, n.p.). There are subcategories of informational texts including narrative nonfiction texts, expository texts, and mixed texts. Narrative nonfiction texts are often used to share information about people and historical events (Stewart & Young, 2018) and are written using a story structure or as a series of events. For example, *The Boy Who Loved Math: The Improbable Life of Paul Erdos* (Helligman, 2013), a picturebook biography written in narrative, shares childhood events from the life of a renowned mathematician. Expository texts are meant to explain or describe topics related to the physical, social, or natural worlds. For instance, *Anno's Counting Book* (Anno, 1977) helps children understand mathematical concepts such as counting, cardinality, one-to-one correspondence, sets, and change over time as they occur in the natural world. Mixed texts include both narrative and expository writing as seen in *The Animals Would Not Sleep!* (Levine, 2020), a fictional story about sorting animals with an expository piece at the end explaining different animal categories (e.g., amphibians, arthropods).

This study focused on math books found in first-grade classroom libraries that were identified as expository or mixed texts as defined above. Though many narrative fiction books contain mathematical ideas (i.e., *Lia & Luis: Who Has More,* Crespo, 2020), they were not the focus of this study.

Literature Review

Over several decades, scholars have studied early childhood (prek-3rd grade) classroom libraries examining such things as their frequency of use, their design, and children's books selection strategies. This literature review begins by focusing on studies about teacher selection criteria for their classroom libraries, the text-types found within the libraries, and the content of the books in the libraries. It concludes with a review of the literature surrounding the analysis of the content found in math-related trade books.

Classroom Library Book Selection

Teachers use various criteria to select books to include in their early childhood classroom libraries including the cost and reading levels of the books as well as the interest of their students (MacKay et al., 2020). Though some teachers are more concerned with the size of their classroom library than the quality or content of the books they select. MacKay et al. (2020) found that some first-grade teachers do consider whether a book aligns directly to their curriculum goals however, none specifically mentioned mathematics connections as a book selection criterion. In this same study, researchers found that many teachers are intentional about including nonfiction (i.e., nonfiction narrative, expository, mixed) texts in their classroom libraries which could include expository books supporting mathematical thinking.

Text-Types in Classroom Libraries

In 2010, the NGACCSS recommended a 50–50 balance between informational and literary reading and instruction, also advocated for by literacy experts (Dreher & Kletzien, 2015; NGACCSS, 2010b). Because this emphasis on the importance of children accessing informational literature, there has been an increase in the number of these texts found in early childhood classroom libraries. Over twenty years ago, Duke (2000) found that only 11% of the books found in early childhood classroom libraries were informational books (i.e., narrative nonfiction and expository). In contrast, twenty years later MacKay et al. (2020) found a substantial increase in the percentage of expository (22.8%) or mixed texts (10.2%) in first-grade classroom libraries.

Few researchers have looked at the specific disciplinary content of the informational texts found in early childhood classroom libraries. Crisp et al. (2016) completed a content analysis of 1169 narrative and expository books found in classroom libraries to understand how diverse cultures, ethnicities, socioeconomic status and classes, sexuality identities, religions, and genders were represented. Hodges et al. (2019) analyzed 50 classroom libraries to determine the number of books found on the National Council for Social Studies notable book list (both narrative and expository). No scholars have analyzed the mathematics content of the books found in early childhood classroom libraries.

Evaluating Math Books

Some researchers have examined the mathematical content and/or the quality of mathematics found in children's trade books in general. Nesmith and Cooper (2010) indicated that prior analyses of the quality of mathematical content in these books were based on Likert scale ratings which varied depending on the creator's mathematical understanding. Nurnberger-Haag (2017) specified that research should create separate criteria for each domain of mathematics displayed in children's books. This is evident in the work of Ward et al. (2017) and Powell and Nurnberger-Haag (2015), who examined the content related to number concepts in children's books, while Nurnberger-Haag (2017) examined shape content.

In examining the Common Core State Standards for Mathematics (CCSSM) for first-grade, place value and number sense are key objectives (NGACCSS, 2010c). Students are working through counting, addition & subtraction, and the concept of base ten to develop these key ideas. Powell and Nurnberger-Haag (2015), however, found that in the children's books they studied there was limited opportunity to learn the number zero and numbers beyond 10 as well as limited exposure to multiple representations of numbers, which are supportive of building number understanding. Ward et al. (2017) also detailed in the books they examined that there were features supporting the development of counting, but also distractors and elements that may inhibit students' sense-making of counting.

Nurnberger-Haag et al (2020) highlighted that previous rubrics for detailing mathematical accuracy within children's books used a Likert scale that averaged a rating across other scores for the book, thus minimizing the mathematics within the book. Both the Ward et al. (2017) and the Powell and Nurnberger-Haag (2015) studies used descriptive statistics to explain the characteristics found in children's books focused on number. Ward et al. (2017) analyzed 120 counting trade books intended to be a sample of books for children from birth to five found in the university and the public library system, while Powell and Nurnberger-Haag (2015) analyzed 160 number trade books thought to be a representative sample for parents and teachers. These were found through a relevance and popular title search through Amazon, from four elementary school library media centers, from two public libraries, and from three teacher researchers' personal collections.

While Ward et al. (2017) and Powell and Nurnberger-Haag (2015) provide important descriptions of the mathematics around counting and numbers in these selected trade books, this paper examines the mathematical content in expository books found within first-grade classroom libraries. These are books most accessible to children during the school day. This provides a glimpse into the mathematical content of books that students in early childhood settings may encounter as they engage with the books in their classroom libraries. The following questions guided this study:

1. What mathematical concepts are presented in books found in first-grade classroom libraries related to counting/cardinality and/or operations/algebraic thinking?
2. How do these concepts align with the first-grade Common Core State Standards for Mathematics (CCSSM)?

Methods

The research method employed for this study was conceptual content analysis. Conceptual content analysis is "a research technique for the objective, systematic, and quantitative description of the manifest content of communication" (Berelson, 1952, p. 489) used to determine the existence and/or frequency of something in a text (Krippendorf, 1980). It can uncover the presence of specific words, structures, concepts, or themes within the data (e.g., books, newspapers, speeches). In this study, the researchers looked for specific mathematical concepts represented in books found in first-grade classroom libraries thus making content analysis an effective research tool.

The Data Set: Background and Past Analyses

The data for this study came from an existing database containing the contents (books and magazines) found in early childhood classroom libraries. A classroom library was defined as books available to students to access for independent reading. The database of over 13,000 titles, created in 2017, contains the contents of 23 first-grade classroom libraries from four school districts (three urban-suburban, one suburban-rural as classified by the state board of education) located in the Intermountain West representing different Socioeconomic Status (SES) populations and years the teacher had been teaching.

This database was previously analyzed on three hierarchical levels: (a) text-type, (b) content-area, and (c) content-area sublevel. The first level of analysis assigned each title one of seven text-type codes as seen in Table 1 (MacKay et al, 2020). During the second level of analysis, researchers examined the 4290 texts previously identified as expository or mixed text-types to determine the content areas represented in each. Some books did not clearly represent a content area and thus were coded differently (e.g., cooking and recipe books were coded as *Recipes*). Books covering two content areas were assigned two codes, one for each content area, and magazines covering more than two content areas were coded as *Magazines* (see Table 2 for Level 2 coding categories). The third level of analysis determined

Table 1 Level 1: classroom library text-type coding categories

Narrative	All texts (fiction and nonfiction) written to tell a story. Does not include biographies
Expository	Nonfiction texts written to explain or describe
Mixed	Texts containing both narrative and expository writing
Poetry	Poetry collections and anthologies
Other	Joke books, activity books, reference books (e.g., dictionaries)
Biography	Texts written to tell the story of a person's life
Alphabet	All texts written using an alphabet structure

the sublevel of each book in each content area. For example, if a book was coded as *Mathematics* in the Level 2 analysis and was a counting book, sublevel three coding was Counting and Cardinality. A book containing content in multiple sublevels, were assigned codes for each. Table 3 illustrates the codes used in this third level of analysis for math-related texts along with the total number of texts (and percentages) containing the content in the sublevel categories. Other content-area texts were analyzed at the sublevel but were not the focus of this study.

Level 4 Data Analysis

For this study, the research team consisted of three university faculty members, each with expertise in different areas (mathematics education, children's literature, and early childhood education) and four research assistants. This team conducted a fourth level of content analysis to answer the research questions about the mathematics concepts presented in books found in first-grade classroom libraries and how these concepts aligned with the CCSSM.

Table 2 Level 2: classroom library content-area categories

Content area	Category description
English language arts	Reading, writing, speaking, listening, parts of speech
Fine arts	Dance, drama, visual arts, music
Health	Physical health, mental and emotional health, safety, human development
Mathematics	Numbers, operations, measurement, data, geometry
Physical education	Motor skills, fitness, sport rules/equipment
Science	Physical, chemical, life, earth, space sciences
Transportation	Land, water, air, space
Recipes	Cooking, recipes
Reference	Reference books such as dictionaries, encyclopedias
Magazines	Magazines containing content from more than three content areas

Table 3 Level 3: classroom library mathematics sublevels, totals, and percentages

Category	Total	Percentage of total books (%)
Counting and cardinality	250	6
Geometry	37	.1
Measurement and data	96	2
Operations and algebraic thinking	74	2

Level 4 analysis involved the mathematics books coded as sublevels Counting and Cardinality and Operations and Algebraic Thinking in Level 3. All books were picturebooks with publication years ranging from 1969 to 2017. Duplicate titles within and across libraries were eliminated, bringing the total number of books in these sublevels to 140. These specific sublevels were selected because they comprised the largest number of books (counting and cardinality) and highlighted opportunities for student learning of number concepts. Level 4 analysis consisted of two coding rounds. Round 1 focused on early number concepts and Round 2 focused on the connections between the mathematical concepts found in the books and the CCSSM for first-grade.

Round 1: Counting and Cardinality and/or Operations and Algebraic Thinking

In the previous analysis and categorization of the book, the extent of the mathematics was noted to be limited. For this purpose, we sought to capture how numbers and sets were represented in the 140 books, how counting principles were used and extended, and how operations were represented.

For the first round of analysis, we used an adapted version of the evaluation instrument established by Ward et al. (2017). Specifically, we used the *features of numbers* section of their evaluation. This tool allowed us to analyze counting and cardinality along with the associated representations and basic operations in each of the texts. The evaluation with books began with number representation (Arabic, number word, set) and counting format (ascending, descending, skip counting, non-sequential). The evaluation then moved into the counting principles of one-to-one correspondence, constancy, counting sequence, and cardinality. Other items analyzed were ordinality, the link between the number and set representations, and the mathematical operations of addition, subtraction, multiplication, and division. A test library of selected math books was used initially to refine the coding. This led to the adaptation of the instrument as issues arose in the test books that were not captured in the

instrument or where more detail was needed for our analysis. These added components and clarifications are in Table 4.

The added components and clarifications ranged from capturing whether counting or number words were written in another language to adding a code for grouping/organizing and for place value. The first adaptation was to consider a number word set and the language it was written in. For example, in the book, *We All Went on Safari: A Counting Journey through Tanzania* (Krebs, 2017) number words were written in Swahili next to the numeral. Ward et al. (2017) captured the counting principles of one-to-one correspondence, however it did not capture the number range, so we added that component. We also added the code *number sequence* and included ranges up to 100+. We used the same coding for constancy as Ward et al. (2017) but added an additional constancy code to distinguish whether the change in arrangements of the sets occurred on the same page versus over multiple pages.

The detail of mathematical concepts was also extended to the potential mathematical operations presented in the books and the addition of grouping and place value. For the operations we added details to code whether the representation was visual and if/how it was connected to symbolic notation and whether the book dealt with the operations with one-digit, two-digit, or three-digit numbers. Grouping/categorizing codes were added as a precursor to multiplication, division, and place value. A code was added to capture content related to representations of place value.

Before the books from the data-set were analyzed, a test library was used to create a reliable coding protocol. Once established, the books from the first-grade classroom libraries were coded by two research assistants sitting side-by side, each with their own evaluation instrument. Both research assistants independently evaluated the same text and then compared their evaluations. When there was disagreement, they discussed their differences and explained their thinking to find agreement. If they could not, the book was brought to a weekly team meeting and discussed until consensus was reached. During the beginning of the process, several books were brought to the whole team for discussion but as the coders became more comfortable in their evaluations, this occurred less often.

Round 2: First-Grade Mathematics CCSSM

This research sought to capture how these classroom books aligned with the concepts covered in class as a support to student learning. The Ward et al. (2017) evaluation was intended for preschool math concepts, not necessarily aligned with grade level standards. Thus, although the Ward et al. (2017) evaluation tool provided important insight into the desired mathematical concepts, further investigation was needed to depict the alignment and support for first-grade standards. An additional evaluation tool was generated based upon first-grade standards within the Operations and Algebraic Thinking domain as well as some of the Numbers and Operations in Base Ten domain (CCSSM).

For round 2, 44 books were assessed, with the standards used as the criteria in which to assess these books (see Table 5). These books were analyzed because in Round 1 of coding they contained mathematical operations connected to first-grade standards. The other 96 books analyzed in Round 1 contained concepts of counting and number, but not operations. Table 5 depicts the evaluation tool for Round 2 as it relates what is happening in the context of a book to the type of word problem situation and details what type of strategies for operations are presented. The story problems evaluated consist of adding to, taking from, put together/take apart, and compare situations. These story problem categories include the various unknowns (i.e. result, change, start, etc.) within each of these types. For this evaluation, story problems were coded as situations that aligned with these story problem categories as written in the context of the book. For example, in *Two Little Witches: A Halloween Counting Story* (Ziefert, 2007), each page spread presents an adding-to story problem inviting the reader to find the solution:

> S*ix trick-or-treaters going trick-or-treating.*
> *If six trick-or-treaters meet one orange pumpkin, that makes...* (np).

Strategies for operations were examined by looking for use of properties, whether there was counting on or counting backwards, and/or relating addition with subtraction. The coding protocol for Round 2 was the same as for Round 1.

Results

Below we present the descriptive statistics for the 140 books in our Level 4 data analysis. The results are organized to address each of the research questions: (a) What mathematical concepts related to counting and cardinality and operations and algebraic thinking are presented in books found in first-grade classroom libraries? and (b) How do these concepts align with the CCSS for first-grade mathematics?

Round 1: Counting and Cardinality and/or Operations and Algebraic Thinking

This round of analysis found that most of the math content in the math books in first-grade classroom libraries correlated with preschool or kindergarten content. Details of this content as it relates to counting and cardinality, and operations and algebraic thinking are discussed below.

Table 4 Additional features of numbers evaluation (added to Ward et al., 2017)

Coding Category	Level 1	Level 2	Definition/Example/Checklist
Number Representation and Type	Languages		___ written in words in another language List written language: _____
Counting Principles	1-to-1 Correspondence	Number Range	___ 1-5 ___ 6-10 ___ 10-20 ___ 20-30 ___ 30+
	Counting Sequence		___ 1-5 ___6-10 ___11-12 ___ 13-20 ___ 21-30 ___ 31- 40 ___ 41-50 ___ 50-100 ___ 100+ ___ Also includes 0 ___ Skip counting by 10's (10,20,30…) up to ____ ___ Skip counting by 5's (5,10,15…) up to ____ ___ Skip counting by 2's (2,4,6…) up to ____ ___ Skip counting by other ____ up to ____
	Constancy 1 (must be more than 1)	Implicit	___ More than one representation of the same set with different arrangements. (e.g., ▼▼▼▼ ▼▼ ▼▼) (Can be on different pages but number or number word needs to appear on both pages.)
		Explicit	___More than one representation of the same set with different arrangements and rearrangement is highlighted. (e.g. - "If we spread them out it is still four." ▼▼▼▼ ▼ ▼ ▼ ▼)
	Constancy 2 (must be more than 1)	Implicit	___ More than one representation of the same quantity on a page with different arrangements. (e.g., ▼▼▼▼ ◯◯ ◯◯) (The sets need to be deliberate [e.g., 5 worms, feathers, hens] [9 men playing instruments is a non-example])
		Explicit	___ More than one representation of the same quantity on one page, with different arrangements, and rearrangement is highlighted in text. (e.g., "We have four triangles and 4 circles but they are grouped differently." ▼▼▼▼ ◯◯ ◯◯)
Mathematical Operations	Addition		Words or images representing or implying addition. Plus, add, total, sum, altogether, or use language that indicates addition (e.g., one plus duo equals trio). ___ Visual representation of addition ___ Visual representation connected to symbolic representation ___ Uses symbolic representation of addition only (+ symbol or equation) ___ Single Digit addends ___ Two-digit addends ___ Three-digit addends
	Subtraction		Words or images representing or implying subtraction (e.g., subtract, take away, minus, difference). ___ Visual representation of subtraction ___ Visual representation connected to symbolic representation ___ Uses symbolic representation of subtraction only (+ symbol or equation) ___ Single digit subtrahend and minuend ___ Two -digit subtrahend and/or minuend ___ Three or more-digit subtrahend and/or minuend
	Multiplication		Words or images representing or implying multiplication (e.g., times, multiply, product, '5 groups of 3). ___ Visual representation of multiplication ___ Visual representation connected to symbolic representation ___ Uses symbolic representation of multiplication (x) symbol or equation ___ Single digit multiplication ___ Two-digit multiplication ___ Three or more-digit multiplication
	Division		Words or images representing or implying division. (e.g., divide, separate, quotient) ___ Visual representation of division ___ Visual representation connected to symbolic representation ___ Uses symbolic representation of (÷) symbol or equation ___ Single digit division ___ Two-digit division ___ Three or more-digit division
Grouping Categorizing			___ Groups by color ___ Groups by number (e.g., groups of two items) ___ Groups by size ___ Group by another attribute - Describe attribute_____
Place Value			Place value connection in: ___ Visual representation only ___Visual representation connected to symbolic representation ___ Uses symbolic representation only
	Positions		___ Ones ___ Tens ___ Hundreds ___ Thousands or more ___ Decimals

Table 5 Additional evaluation instrument features based on first-grade standards

Coding category	Level 1	Level 2	Definition/example/checklist
Mathematical operations	Addition and subtraction	Problem-type	___ Adding to: a word problem that contains the action of joining or adding to in the context (i.e., result unknown, change unknown, start unknown)
			__ Taking from: a word problem that contains an action of separating or taking from an amount. (i.e., result unknown, change unknown, start unknown)
			___ Put together/take apart: a static word problem that combines two sets without an action or looks for the amount of one set or both sets (i.e., total unknown, addend unknown, both addends unknown)
			___ Comparing: a word problem that compares two different quantities to see how much more or less are in one set (i.e., difference unknown, bigger unknown, smaller unknown)
		Sum of 3 whole numbers	___ Less than or equal to 20: an equation where three whole numbers add up to a sum that is less than or equal to 20 (e.g., 4 + 2 + 3 = 9)
			___ Greater than 20: an equation where three whole numbers add up to a sum that is greater than 20 (e.g., 8 + 7 + 6 = 21)..\
		Properties	___ Commutative property: this property states that the sum of two numbers is the same no matter the order (e.g., 3 + 4 = 7 AND 4 + 3 = 7)
			___ Associative property: this property states that the grouping of addends does not change the sum (e.g., to add 2 + 6 + 4, the second two numbers can be added to make a ten, so 2 + 6 + 4 = 2 + 10 = 12)
		Strategies	___ Counting on strategy: the counting on strategy is when you count on from the starting or biggest number instead of starting with one (e.g., 5 and counting on 4 more would be "5, 6, 7, 8, 9")
			___Counting backwards: this is when counting starts with the higher number and decreases by one
		Number range	___ Adding within 20: this is when the sum of the equations does not exceed 20
			___ Subtracting Withing 20: this is when the difference stays within the number 20
		Word problems	___ Addition word problems within 20: this is when the sum of the word problem does not exceed 20
			___ Subtraction word problems within 20: this is when the difference of the word problem stays within 20
		Relating to counting	___ Relate counting to addition: an example is when counting on two is the same as adding two
			___ This is when counting backwards two is the same as subtracting two

Counting and Cardinality

The results for this round indicate that numbers were most often represented in the books by number sets, Arabic numerals, English number words, or a combination of two or more of these representations (see Table 6). Thirty-two percent of the texts had clear links between the Arabic numerals and the sets, 11% between number words and the sets, and 2% between the number words and Arabic numerals. It is interesting to note that though eight of the classrooms inventoried had many dual-language students, only three of the books contained number words in a language other than English and only one of these had Spanish number words, the predominant second-language in these schools.

Most often, the books used an ascending counting format with over half of them using a non-sequential number somewhere in the counting sequence. Usually, this was a return to the number that began the counting sequence (e.g., one or zero for ascending counting formats, or 10 for descending formats) as an ending to the book. The counting range

Table 6 Number representation features

Feature type	Specific feature		Number of books (%)	Grade-level math CCSS
Representation type	Arabic		111 (79%)	k
	Number word		102 (73%)	k
	Non-english number word		3 (2%)	
	Sets		130 (93%)	k
	1 Representation		6 (4%)	
	2 Representations		62 (44%)	k
	3 + Representations		71 (51%)	
Links between representations	Sets and Arabic numerals		45 (32%)	k
	Sets and number words		15 (11%)	k
	Number words and Arabic numerals		28 (2%)	k
Counting format	Ascending		87 (62%)	k
	Descending		30 (21%)	
	Non-sequential		74 (53%)	
	Skip counting		24 (17%)	k, 1, 2
		By 2 s	12 (9%)	2
		By 5 s	7 (5%)	2
		By 10 s	14 (10%)	k, 1, 2
		By Other	2 (1%)	2
Counting range	Up to 5		12 (9%)	prek
	Up to 10		68 (49%)	prek
	Up to 20		15 (11%)	k
	Up to 50		1 (< 1%)	k, 1
	Up to 100		6 (4%)	k, 1
	Includes 0	Includes 0	34 (24%)	
Grouping	By color		13 (9%)	prek, k
	By number		40 (29%)	prek,k
	By size		3 (2%)	prek. k
	By other		0	
Place value	Visual connected to symbolic		1 (< 1%)	k, 1
	Symbolic representation only		2 (1%)	k, 1
	Ones place		4 (3%)	k, 1
	Tens place 3		4 (3%)	k, 1
	Hundreds place		3 (2%)	1

for most of the books was up to ten with a small percentage of the books (0.5%) representing counting beyond twenty.

Approximately one third of the books contained some representation of grouping, with grouping by number being the most common type. The concept of place value, a focus within the first-grade CCSSM, was addressed in only about 3% of the texts.

Table 7 illustrates how different counting principles were represented in the books. For one-to-one correspondence and ordinality, explicit representations exceeded implicit representations. Not surprisingly, the opposite was true for constancy 1, constancy 2, and cardinality. In fact, implicit cardinality was the most common counting principle seen in the texts.

Fifty of the books (36%) presented content about number relations. Twelve texts (9%) represented a number and set as being greater than, less than, or equal to one another 35 books (25%) showed the decomposition of sets and three (2%) represented both set comparisons and decompositions.

Operations and Algebraic Thinking

Several of the books contained content about mathematical operations including addition, subtraction, multiplication, and division (see Table 8). About one quarter of the books contained one or more representations of addition with the majority of those discussing/illustrating problems within 10. One-fifth of the books had some type of subtraction-related

Table 7 Counting principles

Principle	Number of books (%)		Grade-level math CCSS
	Implicit	Explicit	
One-to-one correspondence	2 (1%)	23 (16%)	k
Constancy 1	45 (32%)	1(< 1%)	k
Constancy 2	23 (16%)	5 (4%)	k
Cardinality	118 (84%)	13 (9%)	k
Ordinality	1 (< 1%)	5 (4%)	

problems, also mostly within 10. Principles of multiplication and division were minimally included.

After the content-analysis in this round, the researchers compared the results with the CCSSM from kindergarten through third-grade and the Utah Core State Standards for Early Learning (Utah State Board of Education, 2020) to determine the grade-level in which these concepts are typically taught. Many of the books contain only preschool and/or kindergarten content as seen in Tables 6–8. For example, the range for most of the counting books is 1–10, a preschool mathematics expectation. Books with addition and subtraction concepts were mostly within 10, a kindergarten expectation. Very few of the counting and operations coded in these books aligned with CCSSM for first-grade as outlined in Table 9 (e.g., adding and subtracting within 20, properties of operations, relationships between operations, counting to 120, place value).

Table 8 Operations

Type	Representation/digits	Number of books (%)	Grade-level math CCSS
Addition	Words and/or images	33 (24%)	k, 1
	Images only	14 (10%)	k
	Images and symbolic	19 (14%0	k, 1
	Symbolic only	6 (4%)	1
	One-digit + one-digit	31 (22%)	k
	Two-digit + one-digit	4 (3%)	1
	Two-digit + two-digit	2 (1%)	1
	Any three-digit + another number	2 (1%)	2
Subtraction	Words and/or images	28 (20%)	k, 1, 2
	Images only	14 (10%)	k
	Images and symbolic	10 (7%)	k, 1, 2
	Symbolic only	6 (4%)	1, 2
	One-digit – one-digit	24 (17%)	k, 1
	Two-digit – one-digit	3 (2%)	1
	Two-digit – two-digit	2 (1%)	1
	Any three-digit – another number	2 (1%)	2
Multiplication	Words and/or images	11(8%)	3
	Images only	5 (4%)	2
	Images and symbolic	3 (2%)	
	Symbolic only	1 (< 1%)	3
	One-digit × one-digit	5 (4%)	3
	One-digit × two-digit	3 (2%)	3
	Two-digit × two-digit	2 (1%)	3
	Any three-digit × another number	3 (2%)	4
Division	Words and/or images	7 (5%)	3
	Images only	3 (2%)	
	Images and symbolic	2 (1%)	
	Symbolic only	1 (< 1%)	3
	One-digit/one-digit	4 (3%)	3
	Two-digit/one-digit	1 (< 1%)	3
	Two-digit/two-digit	0	3
	Any three-digit/another number	1 (< 1%)	4

Round 2: Alignment with Additional First-Grade CCSSM

After adding the additional first-grade mathematics concepts related to operations and algebraic thinking found in the CCSSM to the evaluation instrument, the researchers completed the coding for Round 2 (see Table 9) and found that most of the 140 books contained no or little first-grade content. Out of the original 140 books, 23 contained addition word problems within 20 and 16 had subtraction word problems with 20 however the results from Round 1 indicated that most of these were only within 10 (a kindergarten standard). Of interest, is that several of these word problems represented the operation concepts of adding to, putting together/taking apart, and taking from. Twenty-one percent of the books had numeral addition problem within 20 (again, most within 10). Some of the books related addition and subtraction to counting representing concepts such counting on or counting backwards. A small number of the books represented the properties of addition (et al., commutative, associative).

Discussion

Out of the thousands of books found in first-grade classroom libraries, very few of the expository or mixed texts contain content related to mathematics and those that do address mathematical concepts most commonly addressed in preschool or kindergarten curricula.

Table 9 First-grade mathematics: operations and algebraic thinking

Type	Concept	Number of books (%)
Word problems	Adding to	14 (10%)
	Taking from	21 (15%)
	Putting together/taking apart	19 (14%)
	Comparing	1 (< 1%)
	Addition within 20	23 (16%)
	Subtraction within 20	16 (11%)
Numeral problems	Addition of three numbers < 20	5 (4%)
	Addition of three numbers > 20	1 (< 1%)
	Addition of two-digit within 20	29 (21%)
	Subtraction two-digit within 20	21 (15%)
Strategies	Addition related to counting	23 (16%)
	Subtraction related to counting	15 (11%)
	Commutative property	4 (3%)
	Associative property	2 (1%)
	Counting on strategy	11 (8%)
	Counting backwards	13 (9%)

Counting and Cardinality

Like Powell and Nurnberger-Haag's (2015) findings, the results of this study indicate the majority of the math-related books located in these first-grade classroom libraries counted in ascending order but did not count past ten. Those books that did, did not count past 100 by ones. This does not align with the first-grade standard of being able to count by ones to 120. Additionally, within these books there is little representation of zero or discussion of place value which is a key first-grade concept.

As Powell and Nurenberger-Haag acknowledged, the authors of this study also found that some counting books "provide[d] children the opportunity to learn certain aspects of numbers and counting better than others" (2015, p. 394). For instance, some books had distractors in the illustrations that may interfere with learning to count (Ward et al, 2017). Other authors utilized the counting book format to address content areas other than math (e.g., *One Tiny Treefrog: A Countdown to Survival,* Piedra, 2023). Other counting books found in the classroom libraries used counting as a vehicle for high-quality illustrations) ranging from dots to clip art to beautiful pictures [e.g., *Museum 123,* (Metropolitan Museum of Art, 2004); *Counting With Wayne Thiebaud*, (Goldman Rubin, 2007)].

Operation and Algebraic Thinking

Although a potentially rich opportunity to incorporate different types of story problems in the books, addition and subtraction problem-types (i.e., join to, take from, put together, take apart, and compare) were limited in what was included. There was at least one book with each type of problem, but more could be included to capture these different scenarios. The addition and subtraction discussed in the books primarily stayed within 20 and demonstrated little connection to the addition and subtraction strategies listed in the first-grade standards. With limited mathematics content and connection to these standards, the books in these classroom libraries provide little opportunity to support students with mathematics concepts they are engaging in during their classroom instruction.

First-Grade Math Content in Classroom Libraries

We urge teachers to find quality trade books that support grade-level math concepts to include in their early childhood classroom libraries. One source with potential for finding such books is those that receive the Mathical Book Prize which are vetted by an award panel consisting of librarians, teachers, mathematicians, and early childhood educators. "The Mathical Book Prize aims to inspire a love of mathematics in the everyday world in children of all ages"

(Mathical, n.d., n.p.). The intent of the annual award is to call attention to mathematically related books for students who already love math and to reach out to students who are not *yet* math-loving students. The books chosen to receive the Mathical Book Prize "are as varied as the intersection between literature and mathematics…." (Mathical, n.d., n.p.). Books selected for the award include expository and mixed texts [e.g., *Billions of Bricks* (Cyrus, 2016), *How Many Jellybeans?* (Menotti, 2012), *Lifetime* (Schaefer, 2013)] as well as fiction and poetry in all the possible formats—picture books, novels and chapter books, and short story collections. The Mathical Book Prize is sponsored by the Mathematical Sciences Research Institute (MSRI) in cooperation with the Institute for Advanced Study (IAS). There are other awards that recognize mathematics books.

The Bank Street College of Education created the Cook Prize to honor "the best science, technology, engineering, and math (STEM) picture book for children aged eight to ten. It is the only national children's choice award honoring a STEM book. The Cook Prize is administered with support from *School Library Journal*" (https://www.bankstreet.edu/library/center-for-childrens-literature/the-cook-prize/, n.d.,n,p.). The award was presented for the first time in 2012. Among the mathematics related books selected are the 2019 Winner *Counting on Katherine* by Helaine Becker (2018) and the 2015 Honor Book *Mysterious Patterns* by Susan C. Campbell (2014). All Cook Prize selections are nonfiction and *Mysterious Patterns* is one of the expository books selected.

In addition, there are several teacher-focused websites that provide possible math-related titles to include in a classroom library based on grade-level. For example, on the *We Are Teachers* website, teacher Elizabeth Mulvahil (2021), lists 22+ amazing picture books about math along with a suggested grade-level(s) for each. For example, she recommends David Adler's *Place Value* (2016), a mixed text in which monkeys learn the importance of understanding the positions of numerals to comprehend their value, a concept children begin learning in first-grade.

The Constraints of Classroom Libraries

One limitation of the study was the poor quality of the classroom libraries. Teachers in the MacKay et al., 2020 study expressed that "any book is better than no book" (p. 278). Consequently, many of the books were artifacts from old reading programs. Most of these books were leveled or decodable readers. Such books are considered textbooks as they were designed for use in formal instruction and are rarely chosen for personal reading (Young et al., 2020). Moreover, textbooks are not considered authentic reading material because they are seldom read outside of school (Duke et al., 2006).

A second indicator of the poor quality of classroom libraries in the MacKay et al. (2020) was the number of old books. The literary quality of these old books was not problematic; it was their condition with tattered covers and missing pages that sends a message to students that reading is not valued in the classroom. The number of textbooks and old books reflect the fact that 83% of 8506 K-12 teachers surveyed reported that they received little or no funding for their classroom libraries (Miller & Sharp, 2018). Thus, teachers often shop for texts at garage sales and seek book donations from retiring colleagues or other sources.

A positive finding in these first-grade classroom libraries was that teachers are making concerted efforts to incorporate more expository texts in their classroom collections which led to an increased number of expository books in first-grade classroom libraries (MacKay et al., 2020). Earlier studies reported expository books accounted for only 7 to 9% of books in U.S. classroom libraries (Dreher & Kletzein, 2015) while MacKay et al. (2020) found that 22.8% of the texts found in the first-grade classroom libraries they inventoried were expository.

Further Research

This work is limited to the mathematical concepts of numbers and operations. Further research needs to be explored in the classroom libraries relating to the concepts of geometry, measurement, and data. In the *Level 3* coding for MacKay et al. (2020), 37 books were coded as having geometry content as well as 42 books were coded as having measurement and data content. Exploring these other books would provide a more in depth and complete understanding of the mathematical content opportunities that students may be exposed to as part of their use of their classroom libraries.

In addition to this work in classroom libraries, there is a need to examine books that are being highlighted as containing mathematical content with awards such as the Mathical Award, Cook Award, and books listed on other websites. Recognizing that all books connected to mathematics do not need to cover all mathematical content, there is a need to continue to examine how new books that become available with a mathematics focus, contain supportive content to be used in the classroom and at home.

Research is needed comparing the math books found in classroom libraries with those found in school libraries and media centers. It might also be interesting to examine the content of all the books in the classroom libraries related to STEM topics.

Declarations

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