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## Elementary School Library Collections: A Content Analysis of Science Trade Books

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## Elementary School Library Collections: A Content Analysis of Science Trade Books

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### Abstract

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In this study, science trade books from the libraries of 10 elementary schools across the United States were evaluated using a science trade book evaluation rubric for their overall quality pertaining to science content, literacy, and critical literacy criteria. Findings indicate that 62% of the books met the overall science content criterion, 99% met the overall literacy criterion, and 41% met the overall critical literacy criterion. The majority of science trade books in each school were life science books, and the majority of books across all schools were 18–23 years old, with many being much older. Implications and recommendations are provided.

**Keywords:** *science trade books, literacy, science literacy, critical literacy, library, librarian, collection development*

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Imagine this scenario in a first-grade classroom: One of Mrs. Johnson's students comes running up to her stating she just broke one of her bones. In a panic, Mrs. Johnson frantically tries to gain more information, asking which bone was broken, what happened to cause the broken bone, where the pain was, all as she is taking swift action to contact the school office to call an ambulance. Now imagine her perplexity and dismay when she learned that the student simply lost her tooth. "Bailey, you did not break a bone; you lost a tooth! A tooth is not a bone!" Mrs. Johnson exclaims with great relief. "Yes, it is, Mrs. Johnson. A tooth is a bone! I learned that in the book I borrowed from the library this week."

A look into almost any elementary school library will most likely reveal a nonfiction section with a selection of science trade books (books published for purchase by the general public and readily available, Morrison & Young, 2008). This aligns with the American Library Association's (ALA, 2018) selection criteria guiding school library professionals to include books that "support and enrich the curriculum" and "incorporate

accurate and authentic factual content from authoritative sources” (School Library Selection Criteria section). The number of these books published each year has grown tenfold since 1900 (Lynch-Brown & Tomlinson, 1998), so they are also found in school classrooms and may even grace the shelves of families’ home collections of books. These nonfiction books can be in the format of picture books, a pleasurable reading source for children, and are frequently used as supplemental sources of science instruction by elementary school teachers. Reasons children prefer science trade books include the notion that they satisfy their desire for causal information—information about processes, items, or ideas that answer their how, why, and where questions. These books also provide links to real-world applications, address students’ reading interests, explore the natural world, and invite students to “experience” science along with the books’ characters and authors (Atkinson et al., 2009; Duke & Bennett-Armistead, 2003). In addition, according to Kelly (2018), when students peruse science trade books, they increase their exposure to science content, and when their teachers read the books aloud to the class, students’ higher order thinking skills are stimulated, a necessary precursor to science inquiry (Smolkin et al., 2015). For these reasons, it is critical that students have access to quality trade books. The information contained in trade books considered to be of high quality must be appropriate to students’ ages and ability levels, engage the reader, be error free, not contain misleading notions about who can and cannot be a scientist, contain accurate information, and contain content representative of all people.

The research literature references several studies related to content analyses of science trade books. These analyses have revealed the presence of science misinformation and inaccuracies (Rice, 2002; Rice et al., 2001) across multiple strands of science trade books (Sackes et al., 2009), the presence of bias toward male (Rawson & McCool, 2014) and White scientists (Ford, 2006), the lack of presence of the nature of science (Schroeder et al., 2009) as well as more positive findings, such as Smolkin et al.’s (2009) determination that science trade books are rich in science explanation. Smolkin et al. examined 43 science trade books for explanatory aspects and found them to be rich in science explanation, particularly causal explanations, as compared to just science facts and descriptions.

In this study, we examined science trade books in elementary school libraries to determine their age, their cataloging accuracy (what science strand they were assigned), and the quality of their science content, literacy features, and critical literacy elements. We sought to answer the following research questions (RQs):

1. What is the quality of the science content presented in the science trade books?
2. What is the literacy quality of the science trade books?
3. What is the critical literacy quality of the science trade books?
4. What are the ages of the science trade books?
5. How many books from the selected elementary schools would fit into each of the following science strands: (a) life science, (b) earth and space science, (c) environmental science, (d) physical science, (e) chemistry?

The original Hunsader rubric first modified by Atkinson et al. (2009) and then modified a second time by Patchett (2015) to include critical literacy criteria was used to evaluate the science trade books in this study for science content, literacy components, and critical literacy criteria. This twice modified rubric is now known as the Modified Analytic Science Trade Book Evaluation Rubric (MASTER; Patchett, 2015). The findings of this study are important in terms of making teachers and school librarians aware of the need to

critically evaluate science trade books prior to purchasing them in an effort to prevent the acquisition of books of inferior quality.

### **Review of Literature**

In this section, we define science trade books, describe them, and examine their history and development. Next, we examine the nature of science in these trade books as well as their science content, accuracy, and currency followed by a discussion of gendered images of science taking place in science trade books. We also examine scientists and race in these books and their literacy elements, graphics and illustrations, and readability.

### **Science Trade Books**

Science trade books (also known as library books) are generally singly authored with text that can be particularly interesting and comprehensible to student readers. In the 1980s, educators began to recognize the value of science trade books and began to add them to their elementary science instruction (Anderson, 1998; Butzow & Butzow, 2008; Mayer, 1995). Science trade book use was expanded, and they began to be perceived as not only significant components of the curriculum (Short & Armstrong, 1993), but also critical motivational tools in science instruction (Ford, 2006). When science trade books garnered more interest and as their frequency of purchase increased, their availability also increased (Lynch-Brown & Tomlinson, 1999).

Science trade books are usually more up to date than traditional science textbooks (Mahzoon-Hagheghi et al., 2018), focus directly on one science concept (Hopper, 2009), accommodate different student reading levels (Lai & Chan, 2020), are more interesting and less confusing than traditional science textbooks (Donovan & Smolkin, 2001), and generate interest and motivation to read (Adams & Phillips, 2016; Barclay et al., 2012; Mantzicopoulos & Patrick, 2011). Additionally, science trade books have story lines that pique students' interest (Butzow & Butzow, 2008); have colorful photos, illustrations, and superior graphics (Coleman & Dantzer, 2016); and are developmentally appropriate to many student independent reading levels (Duke & Bennett-Armistead, 2003). Further, the incorporation of these books increases cognitive functions such as reasoning, remembering, and critical thinking (Carr et al., 2001; Monhardt & Monhardt, 2006; Sackes et al., 2009).

Science trade books introduce science concepts while also including a variety of contexts and cultures, and they allow for differentiated literacy learning (Mahzoon-Hagheghi et al., 2018). Experts contend that the most effective use of science trade books for science content development occurs when teachers read these books aloud to their students at such times when the topic of the trade book coincides with in-class science investigations (Bircher, 2009). Studies have found that students gain more conceptual knowledge and achieve higher test scores on posttests of science facts and vocabulary when children's literature is included to coincide with classroom science activities (Lai & Chan, 2020). A study integrating science trade books into fifth-grade science instruction found significantly higher student scores in the experimental group, which included science trade book reading (Lai & Chan, 2020). Coppens (2019) posits that nonfiction trade books enable students to better understand overarching science unit concepts and learn more about a science topic of interest, and Kuhn et al. (2017) found that the use of nonfiction text in the early grades positively impacts student engagement, reading comprehension, and vocabulary achievement. Though their value as read-alouds is evident in the literature, information texts have been found to make up only a small portion of read-alouds in the early grades (Yopp & Yopp, 2006).

Science trade books have limitations, though; studies have revealed the presence of erroneous science content (Rice, 2002); an imbalance of science field representation, with heavy emphasis (64%) on the life sciences (Ford, 2004); and little to no references to the nature of science (Ford, 2006). Particularly problematic is the inclusion of false or misleading information in science trade books because readers (both children and adults) tend to accept without question what they read in trade books (Alexander et al., 1981; Rice, 2002). Readers who accept information at face value could form misconceptions if the information is inaccurate.

### **The Nature of Science in Science Trade Books**

According to Olson (2008), the nature of science addresses how science is similar to or different from other human endeavors, how scientists do science, how lasting science knowledge is, how technology and culture impact the work of scientists, and the differences among basic science, applied science, and technology. Children need to learn that the methods of doing science are as varied as those who do science, that science is connected with many other human endeavors, and that science is a creative process (Olson, 2008). Olson recommends that all of these elements of science be depicted in science trade books so that students can easily imagine themselves doing science activities and becoming scientists.

Going hand in hand with presenting science as an everyday endeavor is putting a human face on science practices, also an element of the nature of science. The American Association for the Advancement of Science (AAAS, 1990), Benchmarks for Science Literacy, Project 2061, and the Next Generation Science Standards (NGSS Lead States, 2013) emphasize the importance of depicting science as a human endeavor. When science content, pictures, and illustrations present science as an endeavor undertaken by those who look like and have similar characteristics as readers, and when science content, pictures, and illustrations present science as less complex and more humanistic, readers will be more likely to view science as an interesting endeavor and a potential career choice (Farland, 2006).

### **Science Trade Book Content, Accuracy, and Currency**

Science trade books can contain erroneous science content information, and because children frequently accept what is written in a book at face value (Alexander et al., 1981), it is imperative that science trade book information be accurate and current so that students do not acquire misconceptions. Rice (2002) conducted a content analysis of 50 science trade books and found explicit and implicit science misinformation in both text and illustrations. Rice et al. (2001) examined 10 science books about the moon and identified 38 instances in which inaccurate information was presented. These inaccuracies included moon phases presented out of sequence, the moon's size and composition inaccurately portrayed, and an erroneous description of the moon's position in space. In a related study, Sackes et al. (2009) reviewed 73 science trade books across three science strands (physical, life, and earth and space) and found inaccuracies in each strand (all trees have flowers, the moon is stationary, anthropomorphism, etc.), including errors in illustrations (shadows incorrectly positioned in relation to the sun's location). However, Smolkin et al. (2009) examined 43 science trade books for explanatory aspects and found them to be rich in science explanation with no mention of inaccurate content. Smolkin et al. suggested that the trade books used in their study provided a greater explanation of science facts and descriptions than what is found in materials from educational publishers, particularly in the life science area.

In addition, currency can impact accuracy. For example, a science trade book about the solar system written before Pluto was deemed a dwarf planet will state that Pluto is a planet. Although that information was correct at the time of the book's publication, more recent scientific research revealed and required reclassification of Pluto as a dwarf planet. This highlights the critical need for science trade books in collections to be current and regularly weeded. Weeding enables librarians to identify a collection's strengths and weaknesses, and provides a continuous check on collection needs, such as books needing to be mended or replaced (e.g., books with inaccurate information, books with dated content needing to be replaced with books of a newer publication date or more suitable material). The prominent method called CREW (continuous, review, evaluation, and weeding) assists librarians in maintaining quality book collections and uses six criteria for deselecting books (weeding). To weed the collection, librarians systematically and regularly analyze the books in each section of the library based on six factors—misleading, ugly, superseded, trivial, irrelevant, and elsewhere—which are summarized using the term MUSTIE. The CREW guidelines recommend that science books be reviewed (using the MUSTIE criteria) and updated every 3 to 5 years and that books with publication dates 10 years old or older be removed from the collection (Larson, 2008).

### **Gendered Images of Scientists in Science Trade Books**

The research literature also presents conflicting information regarding the representation of female scientists in science trade books. A 2014 analysis of 104 children's books about scientists found that 61% of images depicted male scientists (Rawson & McCool, 2014), and the remaining 39% of images depicted female scientists. This is encouraging on the surface, until one realizes that the 39% was not representative of the population of female scientists at the time of publication, but rather exceeded the total number of female scientists in the United States at the time (26%). This could indicate a contrived effort on the part of book authors and publishers to intentionally feature more female scientists in their books. In addition, a longitudinal study of science trade books on the National Science Teaching Association's (NSTA) NSTA Recommends book lists from 2015–2016 revealed that over 70% of the images of scientists in the books were of males (up from 64% in 2014; Farland-Smith et al., 2017). The most recent study available at this writing (Kelly, 2018) revealed that 77% of images of scientists in 28 books on the NSTA's Outstanding Science Trade Book List were male. This is concerning when considering the findings of a meta-analysis from the past five decades of studies using the Draw-A-Scientist Test (DAST) showing men are still more frequently depicted as scientists (Miller et al., 2018).

### **Scientists and Race in Trade Books**

In 2006, Ford analyzed the racial representation of scientists portrayed in children's literature and found 27 of 31 male scientists depicted were White. Rawson and McCool (2014) also found a racial imbalance of scientists portrayed in the books they examined, with 78% of the images representing White scientists. A study of 210 students in Grades 3–5 investigated students' representations in drawings of scientists (Thomson et al., 2019). The study found that the majority of students (75%) represented male scientists in drawings, and the most common image of a scientist was that of a White male. A 2014 analysis of images in science trade books listed in NSTA Recommends revealed that 95% of the scientists depicted in images were White, and that percentage increased to 97% the following year (Rawson & McCool, 2014). It is critical that scientists portrayed in trade books look like all readers and are people with whom all children can relate. Bishop (1990) affirmed,

Books are sometimes windows, offering views of worlds that may be real or

imagined, familiar or strange. These windows are also sliding glass doors, and readers have only to walk through in imagination to become part of whatever world has been created and recreated by the author. When lighting conditions are just right, however, a window can also be a mirror. Literature transforms human experience and reflects it back to us, and in that reflection we can see our own lives and experiences as part of the larger human experience. Reading, then, becomes a means of self-affirmation, and readers often seek their mirrors in books. (p. ix)

When these mirrors reflect exclusion or absence, readers are marginalized. This lack of a mirrored reflection for children of color was revealed in Hefflin and Barksdale-Ladd's (2001) study in which African American children were interviewed concerning book preferences. The children revealed that they wanted to see themselves reflected in books because they felt a greater connection with the content when that occurred. Moreover, children of color have seen predominantly White images of scientists portrayed in media (books, movies, television shows, cartoons) and, therefore, perceive the images as representative of what is typical, dominant, and culturally acceptable (Wong, 2015). Currently, there are still very few examples of scientists of color in media (May et al., 2020), indicating children of color are less likely to see their own reflections in the books they read.

### **Literacy Elements of Science Trade Books**

The literature lacks studies related to science trade books' literacy-associated features. However, according to Atkinson et al. (2009), and as illustrated in their modified rubric (discussed in the Instrumentation section), desired literacy elements of trade books include (1) adequate content information presented in an organized fashion with appropriate text structures, (2) a vivid and interesting writing style designed to involve the reader, (3) text-relevant graphics and illustrations that appeal to children and are representative of their perspectives, (4) readability and interest levels compatible with readers' developmental levels, and (5) elements (content, style, graphics, text) that complement one another.

Science content presented in a science trade book must be substantial, be logically and creatively presented, be accurate, and convey science practices (NSTA, 2020). The writing style must be vivid and interesting and involve readers. When children read a science trade book that contains vivid, interesting language, their curiosity is awakened (Mahzoon-Hagheghi et al., 2018). When readers are engaged in opportunities for making observations, raising additional questions, and reaching evidence-based conclusions, meaningful learning occurs (Henriques & Chidsey, 1997). Additionally, there is evidence in the literature that science trade books, when utilizing interesting and vivid writing styles, can effectively teach science concepts to children and increase their concept comprehension (Bricker, 2005; Saul & Dieckman, 2005).

### **Graphics and Illustration in Science Trade Books**

Text-relevant graphics and illustrations that are appealing to children and relevant to their perspectives are essential to a quality science trade book. Children often learn as much or more from the visual features of a science trade book than from the text (Pappas et al., 2000). The visual features of a science trade book can also invite readers to ask numerous questions they might not have asked had the graphics not been included (Huck et al., 2001).

Of importance is the relationship among the text, graphical features, and illustrations. The design of graphics and illustrations (type and illustration size, style, and color) must complement the text and increase comprehensibility for the reader, not distract from it, and not be solely an embellishment (Donovan & Smolkin, 2002b; Levie & Lentz, 1982). Text and graphics are positioned to complement each other, not conflict with each other; images must

be high quality and not conflict with the textual content (eLearning Guild, 2017).

### Readability of Science Trade Books

Readability of science text books used in classrooms has been found to be well above the reading level of the learner (Walton, 2002). Science trade books offer the opportunity for learners to read books at their individualized reading level. The Lexile framework (MetaMetrics, 2015) determines the readability of trade books by measuring sentence length and word frequency. However, the Lexile framework method does not predict whether that particular selection of text would be easy or difficult for an individual reader, as the reader is influenced by their motivation to read, background experiences and knowledge, and language erudition (Donovan & Smolkin, 2002a).

We examined science trade books in elementary school libraries to determine their age, their cataloging accuracy (what science strand they were assigned), and the quality of their science content, literacy features, and critical literacy elements.

### Data Sources

Ten public elementary schools from across the United States whose library collections were accessible online via the schools' library management system (LMS) were randomly selected for this study. The LMS is the online system used by librarians to manage and maintain the library's resources and to access pertinent data such as checkout statistics, usage patterns, and overdue book information. Schools were located in the following U.S. regions: Northwest (Washington and Idaho), Southwest (California), Northeast (Massachusetts and New Jersey), Southeast (Florida) and Central (Kansas and Missouri). Two schools from each geographic region of the United States were randomly selected as a data source for this study. Table 1 provides the demographics (geographical location, number of students, percent of students considered economically disadvantaged (ED), number of dollars spent by the school on each student, and race breakdown) for the schools included in this study.

Table 1

#### *Participating Elementary Schools' Demographics, 2018*

School	State	Students (n)	% ED	\$ Student	% White	% Hispanic	% Black
1	WA	477	36.9	5,410	88.1	7.3	1.0
2	ID	144	20.8	13,049	86.3	8.2	0.0
3	CA	451	98.0	5,694	2.5	88.5	7.9
4	CA	600	12.0	4,562	55.0	30.0	1.0
5	NJ	780	50.0	8,755	10.0	46.0	15.0
6	MA	372	17.3	12,081	85.8	6.7	1.3
7	FL	826	26.6	5,621	82.4	11.7	2.3
8	FL	425	65.2	5,621	72.6	12.2	10.7
9	KS	542	26.4	5,489	83.6	12.0	1.7
10	MO	310	55.8	10,411	81.0	10.0	2.0

## **Instrumentation**

MASTER, which allows for the evaluation of both literacy and science elements in science trade books, was the instrument utilized for evaluating the books in this study. Rubrics have been shown to be reliable when accompanied with rater training (Jonsson & Svingby, 2007; Sundeen, 2014) and to have validity evidence, especially when used in instruction (Jonsson & Svingby, 2007; Spandel, 2006). MASTER is the second adaptation of the original Schiro (1977) rubric for evaluating mathematics trade books, which Hunsader (2004) modified to reduce the number of criteria and to reduce or eliminate the relative weight of nondiscriminating or trivial criteria. Atkinson et al. (2009) modified Hunsader's rubric (with her permission) so that it could be utilized to evaluate science trade books, and then validated the modified rubric. Patchett (2015) further modified the rubric to include critical literacy criteria (also with permission).

MASTER asks reviewers to first assess a science trade book's content to determine if it is substantially present, if it is accurate, and if it is up to date. If the reviewer determines the book does not meet one or more of those criteria, it is not further evaluated and is to be considered rejected. If a science trade book meets the content criteria, the content is further examined for its depiction as an "everyday endeavor" or, in other words, as a practice that is depicted in such a way that student readers can see themselves reflected in the books and can imagine themselves participating in the science depicted. For the remaining criteria, the evaluator rates each element using a Likert scale ranging from one to five.

Finally, for both nonfiction and fiction books, the evaluator determines whether the book "respects the reader" by incorporating positive ethical and cultural viewpoints inclusive of gender and race by finding evidence of such in the text. If the answer to this component is no, the book is disqualified from the potential total number of books per the following science strands: (a) life science, (b) earth and space science, (c) environmental science, (d) physical science, and (e) chemistry. Finally, the copyright date of each book in each subject area was recorded.

## **Methodology**

In this section, we identify the theoretical framework selected, data collection methods, and the quantitative and qualitative data analyses.

### **Theoretical Framework**

We approached this study from a constructivist construction of knowledge perspective (Piaget, 1952). Constructivism emphasizes individuals and how they generate knowledge and their own conceptualizations of the world (Gredler, 2005). Within the position of constructivism, we further focused on the concepts of science content presentation, nonfiction literacy, and critical literacy. Science content was a lens for this study because science content presentation in texts impacts reader comprehension, whether readers form misconceptions or can connect to and engage with the science portrayed. Literacy was also a focus as elements such as writing style, graphics and illustrations, readability and interest level, and respectability of readers were considered (Atkinson et al., 2009). Finally, critical literacy was a focus because it influences textual and image analysis representations of race, gender, authority, and culture (McLaughlin & DeVoogd, 2004).

### **Content Analysis**

The methodology selected for this study was conceptual content analysis, an established research method (Berelson, 1952) that involves the systematic, rule-guided empirical analysis of texts and associated images (Bell et al., 2019) to make valid inferences

(Bell, 2001). Content analysis was appropriate because it allowed us to critically examine and interpret science trade books so that we might identify patterns, themes, biases, and meanings (Berg, 2009). Specifically, conceptual content analysis was selected because we intended to analyze the text of each trade book for individual components related to science content, literacy, and critical literacy rather than the relationships among the components (Christie, 2007). In content analysis, selections of text are assigned to codes within a coding scheme (Mayring, 2003); in this study the coding scheme was derived from MASTER. Upon accessing each school's library collection via their LMS, a search of books with copyright dates between 2009 and 2019 in each science strand took place; 11 books (at least two from each strand if possible, depending on the books in each school's collection) were randomly selected for review. Eleven books were chosen to bring the total books in the study to at least 100, with extra books included in the total in case some needed to be omitted. Each book's title, copyright date, ISBN number, and author name(s) were recorded. Available books were gathered from our university's library collection. For those books not held in our university library, interlibrary loans were requested and the books arrived from surrounding area libraries. Next, we independently read and reread each book and applied content analysis.

Having read each book at least twice, in keeping with Atkinson et al.'s (2009) recommendations we noted the author's style and the book's overall composition, layout, and text features. Next, each researcher answered the first three questions in the rubric for each book (Is the science content substantial, accurate, and up-to-date?). If any book did not meet all three criteria, it was not further evaluated. We then continued to evaluate each book for science, literacy, and critical literacy elements as previously described (Patchett, 2015). Each book's scores were averaged and rounded to a tenth of a point, and final evaluation scores were determined. (Atkinson et al., 2009; Patchett, 2015). In addition, via LMS we calculated the total number of science books in each school's library collection, and the percentage of books in each science strand (Atkinson et al., 2009). All scores were averaged across criteria, and two final ratings were provided: one from a literacy perspective (average of value literacy scores across all reviewers) and the other from a science perspective (average of science value scores across all reviewers).

### **Data Collection and Analysis**

Data collection methods included evaluation of 111 selected science trade books in five subject categories (life science, physical science, chemistry, environmental science, and earth and space science) from each selected elementary school using the modified Hunsader rubric. Science trade book evaluative data were compared across researchers (one is a professor of STEM education and one is a professor of library and information science), rectified, and analyzed. Each school's entire library science collection was examined via LMS to determine the strand per school and the number of science books with copyright dates falling within the following ranges: 2019–2014, 2013–2008, 2007–2002, 2001–1996, 1995–1990, 1989–1984, 1983–1978, 1977–1972, 1971–1966, 1965–1960, and 1959 and older. Finally, we made note of any science book misclassifications (e.g., books related to chemistry that are categorized as life science) and recorded any literacy- or science-related awards the books had received.

### **Quantitative Analysis**

The final rating scores of each book were used in the quantitative analysis. Outlying scores were rectified among evaluators. In the case of disagreement, the book was excluded. For example, one book showed animals acting as scientists. One reviewer felt

that animals could not authentically be viewed as scientists whereas the other reviewer felt it was acceptable. In this instance, the book was excluded. Average scores across evaluators were calculated for each book examined. A final reviewer evaluation score was given to each science trade book from science, literacy, and critical literacy perspectives. Percentages of books with acceptable science content, literacy, and critical literacy ratings (scores of 4–5 per MASTER) were calculated across all books and for each school. Lastly, the percentage of books belonging to the following disciplines were calculated for each school and across all schools: life science, environmental science, earth and space science, physical science, and chemistry. Cohen’s kappa was utilized to calculate inter-rater agreement because it has been identified as the measure of choice for content analysis studies (Dewey, 1983). Evaluators agreed on all three criteria across 97 of 111 books; thus, Cohen’s kappa was .87 (87% agreement).

### Findings

Because MASTER was designed so that science content, literacy, and critical literacy were in separate sections, these values of a book can be evaluated independently of one another. Thus, we determined that although a book might score highly in science content, it was entirely possible for the same book to score below the level required for recommendation (4–5) in one or both additional areas (literacy and critical literacy) and vice versa.

### Disqualifications

Some books met the criteria for disqualification. Three books (2.7%) contained inaccurate science content, so we removed them from further consideration. In addition, six books (5.4%) were disqualified because the science content was too minimal and/or the books contained more aspects of fantasy rather than factual science. Those nine books were replaced with nine other books to bring the total number of books examined back up to 111. These actions were in keeping with MASTER, which requires books that do not contain substantial science content, contain inaccurate science content, contain old content that is not up to date to not be further evaluated.

### Science Criteria

This section provides findings related to the science criteria. Table 2 presents an overview of these criteria.

Table 2

#### *Science Criteria*

Science criterion	Percent met (scored 4 or above)	Percent not met (scored below 4)
1: Science as an everyday endeavor	68%	32%
2: A human face on science	49%	51%
3: Intellectually and developmentally appropriate	90%	10%

### Science Criterion 1

In this criterion, 68% of the science trade books presented science as an everyday endeavor, and 32% did not. As a positive example of this criterion, consider this excerpt from Burgan's (2016) *Genetic Engineering*: "If you slice an apple and let a piece sit out, it soon turns brown. But what if you could alter the genes of an apple so it would stay fresh longer? That's how the Arctic apple was created" (p. 7). Here, Burgan has the reader consider a common problem with sliced apples turning brown and how that might be resolved if the genes of the apple could be manipulated. As another example, in Space-tacular, Kulavis (2011) connected the sun's light energy with sunburn on human skin and shared astronauts' favorite space snacks. And Kay's (2019) *Stinky Science: Why the Smelliest Smells Smell So Smelly* gives readers scientific explanations for common stinky smells, thus allowing readers to connect the content to their own experiences.

Of the books that did not present science as an everyday endeavor, scientific information was factual and the books provided information only. There was nothing provided in the text, graphics, or illustrations to engage readers or get them to consider participating in related science investigations.

### Science Criterion 2

Roughly half of the books in this study (49%) put a human face on science, whereas 51% did not. As a positive example, in *The Man Who Invented the Laser: The Genius of Theodore H. Maiman*, Wyckoff (2013) depicted Maiman as an everyday person who accomplished an amazing task in spite of many naysayers who did not believe in him. In addition, in Latham's (2013) *Backyard Biology: Investigating Habitats Outside Your Door With 25 Projects*, readers are encouraged to participate in their own science investigations in local parks, playgrounds, and nature preserves as well as their own yards: "Discover life over your head, under your toes, and all around you. Ask questions, make predictions, and record your observations. Think like a scientist. And have fun connecting with the astonishing natural world" (p. 2). Finally, in *A Black Hole Is not a Hole*, DeCristofano (2012) likens the sizes of black holes (small, medium, and large) to the three bowls of porridge in *Goldilocks and the Three Bears*, which is a comparison most readers can relate to.

On the other hand, most of the examined books (51%) did not present science as a human endeavor. For example, in *All About Animals in Winter* (Rustad, 2009), connections could have been made between bears' thick fur and warmth and humans' clothing and warmth but were not. Many books presented science content alone, without the presence of scientists engaging in investigation, sending a nonhumanistic message about science, and/or the content was so complex that readers may not be able to imagine themselves as capable of science investigation. Additionally, many authors of life science books about animals did not make a connection between animal and human characteristics and behaviors, when such connections could have helped readers better comprehend and remember why animals behave the way they do and have specific characteristics.

### Science Criterion 3

Regarding this criterion, 90% of the books were appropriate to the designated audience's intellectual and developmental levels, but 10% were not. All of the inappropriate instances involved content too advanced for the designated grade level and age range. For example, in Bang and Chisholm's (2014) *Buried Sunlight: How Fossil Fuels Have Changed the Earth*, the designated age range is 4 to 8 years old. Whereas 8-year-olds could comprehend the content, it is unlikely that most 4-year-olds would be interested in

or understand fossil fuels, photosynthesis, and global warming. And in *Robots in Space* (Clay, 2014; also recommended for ages 4–8), the descriptions of a robotic arm on the International Space Station would likely not interest and could be too advanced for a 4-year-old.

### Literacy Criteria

This section provides the findings related to the literacy criteria. Table 3 presents an overview of these criteria.

Table 3

#### Literacy Criteria

Literacy criterion	Percent met (scored 4 or above)	Percent not met (scored below 4)
1: <i>Fiction</i> : good plot development, well-developed characters, continuity; <i>nonfiction</i> : adequate information, clearly organized, appropriate text structure	96%	4%
2: Vivid and interesting writing style, involves reader	56%	44%
3: Text-relevant and appealing illustrations/graphics representing a child's perspective	98%	2%
4: Readability, developmentally appropriate	62%	38%
5: Content, graphics, and story/text are complementary	98%	2%
6: Access features offer additional information	100%	0%

#### Literacy Criterion 1

Of the 111 books examined, 96% scored either a 4 or 5 for this criterion (adequate, organized information and text structure). Four percent did not. One book seemed to have a page out of sequence; it showed astronauts blasting off and then the next picture with associated description depicted astronauts belting and suiting up in preparation for blastoff. In another book, the last few pages were very text heavy in comparison to the majority of the book. In yet another, the text was white and scattered across the pages were molecules that were also white, making for a distracting presentation for students with vision problems or attention difficulty, hyperactivity, or impulsiveness.

#### Literacy Criterion 2

Pertaining to this criterion, 56% of the examined books scored either a 4 or 5 (vivid and interesting, involves reader). Authors utilized various approaches to create vivid writing styles. For example, in Prager's (2014) *Sea Slime: It's Eeuwy, Goey, and Under the Sea*, an element of mystery was included in descriptions of undersea creatures and the

word “slime” always appeared in a dripping font. In Keating’s (2016) *Pink Is for Blobfish: Discovering the World’s Perfectly Pink Animals*, readers are asked questions that prompt comparisons between themselves and animals. And Suzuki’s (2012) *You Are the Earth: Know Your World So You Can Help Make It Better* immediately pulls readers into the topic: “You probably don’t think much about air. You can’t see it, hear it, or grab a handful of it. It’s almost as if it weren’t there. And yet it’s just about the most precious thing in the world” (p. 1). In addition, efforts to connect with readers occur through access features (sidebars, authors’ notes, and activities) and in “I wonder” questions in the text. In comparison, 44% of the trade books examined scored a 3 or below for this criterion. In these cases, text was informational but not vivid and/or no strategies to involve readers were evident.

### **Literacy Criterion 3**

Of the examined books, 98% contained appealing, text-relevant illustrations and graphics representative of a child’s perspective. We perceived this criterion to be particularly strong across the majority of examined books. Illustrations and graphics were colorful, relevant to the content, and appealing to children. Two exceptions were illustrations in one book (designated for fourth through sixth graders) depicting mostly chemical structures, which would not be comprehensible to most children at these grade levels because they have likely not yet received instruction in molecular structures. A second book, about Mars rovers, included more photos of a person than of the rovers.

### **Literacy Criterion 4**

Ninety percent of the books examined were deemed developmentally appropriate in terms of readability and interest levels for their intended audiences. Among the 10% that scored below a 4 were books with concepts or vocabulary too complex for their intended audience and one book (about fossil fuels for preschool to grade 3) whose content was deemed likely uninteresting to preschoolers, Kindergarteners, and perhaps first graders. In addition, four texts that scored below a 4 in this category did not contain audience-level information, nor did numerous internet searches produce such information.

### **Literacy Criterion 5**

Of the books examined, 98% met this criterion with a score of 4 or 5. Many of the books contained consistent patterns of content presentation, such as a photo appearing first, followed by a comic and then a selection of text. For example, in Keating’s (2016) *Pink Is for Blobfish*, the presentation pattern consisted of an “is for” statement—“Pink is for x” (blobfish, pink-toed tarantula, etc.)—followed by a photo of the organism. On the following page was anecdotal information about the organism on the left and scientific information in a sidebar on the right. Among the 2% of books that did not score well in this criterion was a book with white text in a very small font on a light green background, making it very difficult to read.

### **Literacy Criterion 6**

An examination of books for the final criterion in the literacy category revealed that 100% met this criterion. All of the books examined in this study included access features that served to advance readers’ understanding of the texts with further explanations, extensions, and verifications of content. Access features included “notes about this book” containing additional related topics, lists of resources from which readers might learn more about the topic, procedures for hands-on science investigations related to the content of the book, links to related online resources, additional information about the author, and so on.

## Critical Literacy Criteria

This section provides the findings related to the critical literacy criteria. This category appeared to be most problematic (and, therefore, given more consideration in the explanation), with over half of the 111 books (59%) scoring below a 4 and 41% scoring a 4 or 5. (Patchett, 2015) Table 4 presents an overview of these criteria.

Table 4

### *Critical Literacy Criteria*

Critical literacy criterion	Percent met (scored 4 or above)	Percent not met (scored below 4)
1: Positive ethical and cultural values inclusive of gender and racial representation	44%	56%
2: Presence of non-represented or underrepresented groups	39%	61%
3: Two or more cultures represented	39%	61%
4: Presence of multiple cultures with authority	16%	84%
5: Presence of social, ecological, or political topics	55%	45%
6: Promotes discussion-rich dialogue	44%	56%

### **Critical Literacy Criterion 1**

Findings indicate that 44% of the books examined met this criterion. Among the 56% of books not meeting this criterion were those that were informational only and did not engage the reader in ethical or cultural considerations and those that depicted the actions of White males (and therefore only their ethics and cultural values) exclusive of everyone else. Among those that met this criterion were books such as Bang and Chisholm's (2014) *Buried Sunlight*, which discusses the consequences of the warming of the Earth due to humans' actions; Orme's (2009) *Garbage and Recycling*, which includes a discussion of what garbage does to the environment; and Furstinger's (2014) *Everglades: The Largest Marsh in the United States*, which advises readers about what they might do to protect the Everglades and the organisms that live there.

### **Critical Literacy Criterion 2**

Of the books examined, 39% showed the presence of historically nonrepresented or underrepresented groups, whereas 61% did not.

### **Critical Literacy Criterion 3**

Regarding the presence of two or more cultures representative of the real world, 39% of the examined books met this criterion, but 61% did not.

### **Critical Literacy Criterion 4**

Of the books examined for whether multiple cultures had positions of authority in the texts, 16% met this criterion, and 84% did not.

### **Critical Literacy Criterion 5**

Regarding the presence of social, ecological, or political topics typical of the real world, 55% of the books met this criterion, whereas 45% did not.

### **Critical Literacy Criterion 6**

Forty-four percent of the books were found to promote discussion-rich dialogue, but 56% did not.

### **Age of Science Book Collections**

The copyright dates of all science nonfiction books listed in each school's LMS were recorded and grouped into the following 5-year time periods: 2019–2014, 2013–2008, 2007–2002, 2001–1996, 1995–1990, 1989–1984, 1983–1978, 1977–1972, 1971–1966, 1965–1960, and 1959 and older. The Missouri school closed during this study, so we were not able to obtain data pertaining to copyright dates of their book collection. In five of the remaining nine schools, the majority of nonfiction science books were in the 1996–2001 category; thus, most science nonfiction books in the schools in this study were 18 to 23 years old. The school with the most current science trade book collections was school 9 (KS), with 47% of its science nonfiction books having copyright dates between 2002 and 2007.

### **Strands**

Our findings support previous studies cited in the literature regarding strands of elementary school-level science trade books in that, across all selected schools, the largest number of science trade books were of the life science strand (Brunner & Abd-El-Khalick, 2017; Ford, 2004; Reardon & Broemmel, 2008). However, a close examination of books in each LMS revealed a problem related to book strand classification. Many books had been misclassified as physics that should have been classified as life science, earth and space science, environmental science, chemistry, or even physical fitness. For example, a book on the life of Helen Keller was classified as physics, and many books about various animals were also classified as physics. In addition, several life science books had been misclassified as physical fitness, environmental science, and earth and space science. The discrepancies in how books are classified are most likely due to how librarians and catalogers choose to enter each book's information into the LMS. Student users must utilize a Boolean keyword search to look for books by subject, which can result in books appearing that are mismatched to the search.

### **Discussion**

In this section, we discuss the results of the five research questions and provide connections for each to the broader field.

#### **RQ1: Quality of Science Content**

This study found that approximately one-third (34%) of the examined science trade books scored below a 4, meaning they did not contain the quality of science content to be credible enough to be recommended for purchase. This is consistent with Rice (2002), who found both implicit and explicit science information in text and illustrations in the science trade books examined in her study. Three of the 111 books examined in this current study contained erroneous science information. In keeping with the requirements of the modified Hunsader rubric, any book with inaccurate science content is to be disqualified from further evaluation, thus those three books were excluded from the study. Students

who read science trade books whose science content is not credible are more likely to pick up misconceptions and misunderstandings that may lead to long lasting conceptual misunderstandings (Owens, 2003).

Conversely, when the content in science trade books is accurate, readers can learn from reading these books by making observations, raising questions, and reaching evidence-based conclusions (Castle & Needham, 2007). Authors, illustrators, and publishers of science trade books must become more diligent about ensuring the accuracy and credibility of the information in these books. School librarians need to be trained in how to select appropriate science trade books that contain accurate and up-to-date science information. They, in turn, can provide professional development to teachers so that selections made for teachers' classrooms have a high level of science content.

The most problematic science criterion in this study was depicting science as an everyday endeavor. This study showed that just over half (51%) of the science trade books did not put a human face on science. Aligning with Bishop's (1990) thoughts regarding mirrors, windows, and sliding glass doors, authors must present the personal side of doing science and being a scientist, the collaborative nature of scientists, and the creative and imaginary aspects of science investigation in order for children to perceive themselves as scientists. Additionally, authors need to be sure they convey to readers that scientists do not always follow the step-by-step procedures of the scientific method.

### **RQ2: Literacy Quality**

The overall literacy features of 99% of the 111 books received acceptable scores of either 4 or 5. The criterion that usually resulted in a score of 4 rather than 5 was related to the author's writing style: whether or not it was vivid and interesting and involved the reader. Texts that scored well in this category included strategies to engage the reader. An excellent example is Hamilton-Waxman's (2012) *Exploring the International Space Station*, which includes these engaging lines:

Imagine waking up in a sleeping bag. But you aren't in a tent. You aren't even on the ground. You're attached to a wall. Outside your window lies the bright, blue earth. You float out of your sleeping bag to start the day. It's just another morning on the International Space Station. (p. 4)

Another example is Hirsch's (2011) *Science Lab: The Life Cycle of Plants*: "Your mission is to find out how scientists study the life cycles of plants. What kinds of experiments help them understand how plants survive in tough places? What kinds of questions do they ask?" (p. 2).

### **RQ3: Critical Literacy Quality**

Over half of the books examined in this study (56%) did not present positive ethical and cultural values, especially inclusive of gender and racial representation in text, pictures, and illustrations, whereas 44% did. These findings are similar to those of Rawson and McCool (2014) and Farland-Smith et al. (2017), who determined that 61% and 70% (respectively) of images of scientists found in science trade books were male. In addition, our findings are also similar to those of Rawson and McCool regarding the ethnic representation of scientists in the examined science trade books. The images and textual descriptions of scientists were mostly White and male.

When authors feature only White males as scientists, readers might experience stereotype threat (the risk of conforming to one's group stereotypes; Kelly, 2018). As

indicated by Farland (2006), when students see underrepresented individuals portrayed as scientists in trade books, it “broadens their perceptions of who could be scientists” (p. 1189) and opens up that opportunity for themselves. Therefore, the fact that 56% of the books examined in this study were not gender and racially inclusive and could result in readers experiencing stereotype threat is cause for concern.

Thirty-nine percent of the books examined included historically non-represented or underrepresented groups; 61% did not. The findings of this study agree with those of Ford (2006) and Rawson and McCool (2014), who also found a dearth of underrepresented groups in the science books they examined.

Criterion 2 examines only whether underrepresented groups are present in the books, not whether underrepresented groups are included among the scientists in the text or hold positions of authority. Therefore, because 61% of the examined books had no historically non- or underrepresented groups either in the text or in photos, readers may perceive this as a message that these groups are unimportant; the absence of these groups is a subtle form of racism (Fara, 2013). Similarly, 39% of the books examined included two or more cultures representative of the real world, but 61% did not. Furthermore, only 16% of the examined books included multiple cultures having positions of authority in the texts; 84% did not. In some cases, multiple cultures were present but the underrepresented cultures were part of an audience or were engaged in an activity that did not entail authority.

Fifty-nine percent of the examined texts included the presence of social, ecological, or political topics typical of the real world, but 41% did not. According to Atkinson et al., (2009) for students to understand and learn to identify stereotypes, a lack of multiple perspectives, author agendas and social, cultural, and ecological perspectives they must be given the opportunity to read books that include those problematic issues.

It is important for teachers, acting as facilitators, to engage students with texts that provide rich discussions and critical discourse. It is also imperative for teachers to pair trade books with other culturally representative texts for the purpose of promoting discussion-rich dialogue for students. Forty-nine percent of the books examined in this study promoted such discussion, whereas 51% did not.

We felt that the critical literacy criteria were more complicated to evaluate than either the science content criteria or literacy criteria because they involved more subjective judgments, which frequently differ from one person to another. For example, the fourth critical literacy criterion is the presence of multiple cultures having positions of authority in the text. There was some disagreement about what constitutes a position of authority. For example, one book featured astronauts checking the outside of a space shuttle in space; one researcher did not conceptualize the astronauts as holding positions of authority, but the other did. In addition, the fifth criterion relates to the presence of social, ecological, or political topics present in the text that are typical of the real world. Again, we initially evaluated the same book differently because we did not have the same conceptions of what might be social, ecological, or political topics. Also problematic were those books that did not include photos or give reference to humans at all. For example, several life science books focused on animals and did not include scientists or any science investigations. We were initially undecided about whether to rate these books as “not applicable” as far as the critical literacy criteria were concerned or to give them a score of 1 because the critical literacy criteria were missing. Ultimately, we opted to give these books a score of 1 for critical literacy because the rubric gave no instructions regarding circumstances such as these. In the end, we were able to come to 82% consensus regarding all six of the critical literacy criteria across all 111 books.

#### **RQ4: Ages of Books**

The fact that most of the nonfiction science books on the library shelves across all selected schools were two decades old or older is a significant concern. According to Royce et al. (2012), “The ability to have current and cutting-edge information available to children is essential for fostering their understanding that science is a dynamic and ever-changing field” (p. 3). To ensure that science trade books with outdated information do not end up in the hands of students, library personnel must engage regularly in the weeding process.

#### **RQ5: Strands and Classification of Books**

Our findings are in congruence with those of other researchers who found most science trade books are of the life science strand (Brunner & Abd-El-Khalick, 2017; Ford, 2004; Reardon & Broemmel, 2008). However, we also discovered that many books in the LMS across all 10 schools had been misclassified into incorrect science strands. The misclassification of books can lead to students’ unrealized searches for books as well as confusion about classification of books in the science strands. A literature search revealed a lack of studies pertaining to the implications of such miscategorizations.

In conclusion, there are multiple reasons why teachers and school librarians should evaluate science trade books prior to purchase: (1) findings regarding RQ1 indicate that approximately one third of the books examined in this study did not contain credible science content; (2) the vast majority of the books examined (99%) contained appropriate literacy quality; (3) nearly 60% of the books did not present positive ethical and cultural values, nor did they contain racial and gender representation across images (critical literacy elements); (4) most of the books were at least two decades old or older; and (5) most of the books were of the life science strand in addition to many being misclassified. Misclassification can be a result of librarians’ lack of knowledge regarding how to classify books within science strands and leads to challenges and confusion for students when searching for books (Batiacila, 2007).

### **Implications**

In this section, we present the implications of this study for students, teachers, librarians, authors, and book publishers, and we examine limitations of the study as well as options for future research.

#### **Implications for Students**

Because science trade books are often the first introduction a child has to science, this study has significant implications for preschool and elementary-level students. If the science content of a trade book is erroneous, students could develop long-lasting science misconceptions that are difficult to correct. Likewise, readers could develop misconceptions if a science trade book contains outdated information that is no longer accurate. Therefore, a procedure must be in place for evaluating potential science trade book purchases for science content, literacy, and critical literacy.

#### **Implications for Teachers**

The value of science trade books as ancillary resources for teachers is well validated in the literature (Butzow & Butzow, 2008; Heisey & Kucan, 2010; Rice et al., 2001; Yacoubian et al., 2011). Understanding the value of science trade books is particularly important for teachers in STEM education (Mahzoon-Hagheghi et al., 2018). However, teachers must pre-evaluate any science trade book they include in their classroom libraries,

select to read to their class, or recommend for student reading. By doing so, teachers can increase student science and literacy learning (Schreier, 2012). Using quality science trade books adds a variety of multimodal informational and narrative texts to develop students' background knowledge in science (Grysko & Zygouris-Coe, 2020). Science trade books often have appealing covers and colorful graphics, but teachers must look beyond their surface-level appeal and commit themselves to evaluating such books before purchasing decisions are made. If teachers are not comfortable evaluating a science trade book for potential consideration for purchase with a rubric such as MASTER we recommend they seek guidance from their school librarian. School librarians possess the expertise to evaluate literature books for quality of curricular content and appeal to readers. Additionally, they could conduct an internet search for the book to determine if it appears on the NSTA Outstanding Trade Books List or enlist the aid of an individual with a strong science background to help evaluate the book.

### **Implications for Librarians**

Librarians are the information specialists of a school, and thus they are ultimately responsible for the selection and purchase of science trade books that will become part of their school library collections. It is critical that librarians be deliberate in their selection and deselection procedures and evaluate a potential book for accurate and appropriate science content as well as literacy and critical literacy elements. In order for students to locate books that match their search criteria, librarians and cataloguers must take care when entering the information of such books in the school's library management system so that they are correctly classified by science strands. We recommend school librarians provide professional development to teachers in how to select appropriate science trade books for their classrooms so that the selected books contain science information that is accurate and up to date and contain appropriate elements of literacy and critical literacy.

### **Implications for Authors and Book Publishers**

Authors and publishers share in the ultimate responsibility of providing readers with science trade books that contain accurate, current, and substantial science content that is organized and crafted to intrigue student readers. Authors must commit to being more thorough about the content they include in science trade books. Publishers must become more diligent about ensuring the accuracy of science information included in the children's science books they publish. We recommend that both authors and publishers utilize MASTER in the writing and publishing process to ensure the presence of all of these critical elements.

### **Limitations and Future Research**

The sample used in this study was relatively small. Though the population included schools from around the nation, science trade books from only 10 school library collections were examined. A study using a much larger sample size would increase the generalizability of this study's findings. Studies examining each specific science strand for science, literacy, and critical literacy content would be helpful, as would studies that examine every science book in a school's collection.

A study that examines teachers' efficacy in teaching using science trade books would add to the literature, and an investigation into what teachers consider when they make book selection decisions would yield useful information regarding which science genres they prefer over others.

In addition, a study delving into how publishing companies make decisions about

what types of science trade books ultimately get accepted and published and what types do not may reveal why most published science trade books for children are of the life science genre. Further useful information could be gleaned from a study surrounding whether students' science content knowledge is impacted by reading a science trade book.

### **Conclusions**

Science trade books are frequently used by teachers as supplemental resources to the science textbook or curriculum when studying a particular topic. The academic literature indicates that children can learn accurate and current information from science trade books, but they can also learn misinformation that can contribute to the development of science misconceptions that are often difficult to correct. Furthermore, students can acquire misleading notions about who can and cannot be a scientist from critical literacy elements of science trade books. Children can also be turned off to a science trade book when the author does not involve them in the narrative and/or presents dull, methodical text. Therefore, it is imperative that science trade books be evaluated for science content, literacy, and critical literacy elements before purchasing and curriculum integration decisions are made. Science trade books can enhance student knowledge of science content when they are chosen carefully and included alongside classroom science activities. Finally, science trade books must regularly be weeded from school library collections so that books with outdated information do not misinform student readers, and schools with LMSs must pay attention to how books are classified so that students can successfully search and locate books in specific science strands.

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