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Representations of the Moon in Children's Literature: An Analysis of Written and Visual Text

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Abstract

This review focused on the written and visual representation of the moon in 80 children's books, including Caldecott Medal and Honor books over the past 20 years. Results revealed that many of these books misrepresent the moon and even reinforce misconceptions about lunar phases. Teachers who use children's literature that misrepresents the moon may unwittingly promote or reinforce alternative conceptions. Thus, teachers, parents, and library media specialists should be aware of common misconceptions about the moon appearing in children's literature. Such misconceptions may cause students to develop misunderstandings about scientific concepts. Examples of errors in children's literature are discussed.

The moon and its phases are frequent subjects in poetry, art, literature, music, and film, with notable examples including *From Earth to the Moon* by Jules Verne, *Moonlight* by Victor Hugo, and *Moonlight Sonata* by Beethoven. The moon's cycle of phases is one of the most familiar natural phenomena, yet it is also one of the most misunderstood.

One example of these misunderstandings is held by many elementary students and teachers who mistakenly believe the moon's phases are caused by the shadow of the Earth (Callison & Wright, 1993; Cohen, 1982; Dai & Capie, 1990; Kuethe, 1963; Sadler, 1987; Schoon, 1992, 1995; Stahly, Krockover, & Shepardson, 1999; Trundle, Atwood, & Christopher, 2002, 2004, 2006, in press b; Zeilik, Schau, & Mattern, 1999). In reality, the Earth's shadow only falls upon the moon once or twice per year during a lunar eclipse.

Surprisingly, even some graduates of Harvard University have misunderstandings regarding lunar phases. In the thought-provoking video *A Private Universe* (1988), crimson-robed students and even a professor are interviewed on graduation day about the origin of the phases of the moon. Although one student said he had taken astronomy and advanced physics at Harvard, he could not correctly explain the true nature of moon phases, nor could most of his colleagues. In addition, the professor, whom we assume was not a professor of astronomy, could not provide a scientific response either.

Science educators are aware of the misconceptions surrounding lunar phases. The *National Science Education Standards* (National Research Council [NRC], 1996) state that elementary students often have a clear understanding of the shapes and relative positions of the Sun, Earth, and Moon, yet they are still unable to use this information to explain moon phases.

Does it really matter if students or adults understand the phases of the moon? Perhaps not for the purposes of everyday life; yet the familiar cycle of lunar phases, so beautiful and so evocative to the human race, is a phenomenon of nature that begs understanding. Unfortunately, misrepresentations of the moon in children's literature do little to foster this goal. Teachers who use children's literature as well as other print and nonprint materials that misrepresent the moon may unwittingly promote and/or reinforce alternative conceptions.

Using Children's Literature to Teach Science

In part, the inability to explain the phases of the moon may lie in how this concept is introduced to students. Children's first introductions to the moon are often through children's literature in the form of picture books. Parents reading to their children point out "the man in the moon," crescent moons, and "the cow jumping over the moon" as they discuss both the visual and written text with their children. This early experience is built upon as children enter preschool and elementary school settings. Many educators promote the use of children's literature to teach science concepts like moon phases, frequently integrating popular books into science units (Barlow, 1991; Burns, 1997; Butzow & Butzow, 1988, 1990; Crook & Lehman, 1990; Daisey, 1994; Dowd, 1990; Freeman, 1995; Jordan, 1997; Kumar & Voldrich, 1994; Madrazo, 1997; Mayer, 1995; Moser, 1994; Roberts, 1999; Royce & Wiley, 1996; Smardo, 1982). Relatedly, for the past 30 years, *Science & Children*, the National Science Teachers Association's publication for elementary teachers, has published an annual list of outstanding science trade books. These lists endorse children's literature as "a valuable tool for interdisciplinary science teaching and learning" ("Reading & Science," 2003, p. 3). While the practice of utilizing children's literature in the science content may be appealing and even widespread, caution about content accuracy must be exercised when selecting the literature (Eggerton, 1996; Rice & Rainsford, 1996; Royce & Wiley, 1996). Very little research has been conducted that carefully examines the representation of science concepts in children's literature, however (Abd-El-Khalick, 2002; Ford, 2001).

In trying to understand the origin of alternative conceptions about moon phases, Ault (1984) identifies that the problem stems from the misrepresentation of the moon in children's literature. The research of Kazemek, Louisell, and Wellik (2004) supports Ault's assertion. In a study examining how children develop an understanding of the natural world, Kazemek and his colleagues found that children develop their ideas about the moon from a variety of sources, including children's literature. Their findings indicate that a parent reading a picture book can "unwittingly help shape a child's mistaken understanding" (p. 11). Based on the work of Ault and Kazemek et al., using literature that reinforces alternative concepts in the teaching of science concepts clearly causes concern.

Analyzing Lunar Concepts in Literature

Moon phases are included in Earth and space science curricula, textbooks, and science standards at the local, state, and national levels across the grade levels from elementary through college astronomy courses. Also, understanding lunar concepts is a part of scientific literacy targeted in the *National Science Education Standards* (NRC, 1996). More specifically, for grades K-4, students are expected to study the patterns of movement and observable shape changes in the moon. Explaining the cause of moon phases is an expectation for grades 5-8. Therefore,

since these standards-based concepts are included in school curricula, they serve as the framework for analysis of the books selected for review.

Eighty children's books were examined for this current study, including Caldecott Medal and Honor books from the past 20 years. Of these award-winning books, 41 included illustrations of the moon. In addition to the Caldecott books, 39 children's books focusing on the moon as a topic and/or using the moon prominently in the illustrations were analyzed. We selected two notable examples from the 80 books for in-depth, critical analysis: *Papa, Please Get the Moon for Me*, written and illustrated by Eric Carle (1986), and *Moonbear*, written and illustrated by Frank Asch (1993).

These two books have a high recognition factor, are readily available to classroom teachers, and are often promoted for use in teaching the moon phases (Carratello, 1992; Roberts, 1999). Carle's book has received numerous awards, including the Children's Choice Award from the International Reading Association and the Parent's Choice Award in Illustration. Lesson plans utilizing Asch's moon books are included in an American Association for the Advancement of Science (AAAS) (2002) publication. In short, these two books are widely recommended by local school systems, state departments of education, universities, public libraries, science centers, professional associations, and museums for inclusion in teaching science concepts.

Books were identified for inclusion in this study by T. Gail Pritchard, an expert in children's literature. The visual and written texts from all of the books were critically analyzed and compared to actual observational data collected by Kathy Trundle. For purposes of this study, visual text refers to the illustrations and photographs found in the books, while the written text refers to the words. The visual texts of the books were also compared to photographic images of the moon available through the U.S. Department of the Navy's Naval Observatory. The analysis focused on three different types of representations of the moon: (1) shapes, (2) labels of phases, and (3) sequences of shapes. The actual observational data and photographic images of the moon were used for comparison with the books' visual text, especially in regard to shape and sequence. Consistencies and inconsistencies were noted. In addition, the written text from each book was compared to *The Once and Future Moon*, a scientific reference book (Spudis, 1996), and discrepancies were recorded.

Trundle and Thomas Troland, a science educator and astronomer respectively, independently coded and analyzed the visual and written text of the books, using a coding sheet based on previous research (Trundle et al., 2002, 2004, 2006, in press a, in press b). (See Appendix A for the coding sheet.) The visual text was coded by the conceptual representation of the moon. A scientific representation was defined as being in agreement with scientifically accepted norms. Alternative representations were defined as being at odds with scientifically accepted norms (Hewson & Hewson, 1983). The coding sheets facilitated analysis and helped standardize coding between the two reviewers (Coffey & Atkinson, 1996). For each illustration of the moon, the researchers first determined which of the eight representative moon phases (e.g., full, waning gibbous, third quarter, etc.) was drawn or pictured. Next, the researchers determined if the drawing was scientific or alternative by comparing the illustration to the photographic images and observational data of the moon described above. A tally mark was made in the appropriate column, and qualitative notes were recorded in the note sections to explain why the drawing was coded as alternative. The researchers each coded a total of 772 illustrations of the moon for an inter-rater agreement of 87.6%. Codes

from each reviewer were recorded into a data spreadsheet, each of the codes was compared between the two researchers, and discrepancies were identified. A percentage of agreement was determined by dividing the number of codes agreed upon by the total number of codes recorded.

Findings: A Word of Caution

Findings for Selected Books

The following results for six selected books provide specific examples of how the coding was applied to all 80 books. Two of the six books are fiction while the remaining four are nonfiction. Both fiction books were illustrated by the author as were two of the nonfiction books. Three books were selected because all of the illustrations were coded as scientific. The other three books were selected because their illustrations were coded as non-scientific or alternative representations. Table 1 presents information on how each of these books was coded for shapes and sequences. It is worth noting that, in the publication world of children's literature, the author and illustrator generally work independently. The written text is presented to an illustrator, who is chosen by the publisher. The illustrator then interprets the text visually and, in most cases, the author has little input in the artistic process. Because of this independent relationship, it is quite possible to have scientifically accurate written text while the visual text has alternative representations, and vice versa.

One example of scientific representation in a picture book is *Starry Messenger* written and illustrated by Peter Sis (1996). This 1997 Caldecott Honor Book features several observable shapes and properties of the moon, including full, third quarter, waxing crescent, first quarter, as well as lunar craters, valleys, and chasm. In addition, this fascinating picture book contains a depiction of Galileo's journal observations of the moon.

Another example of a picture book with illustrations coded as scientifically accurate is *One Giant Leap: The Story of Neil Armstrong,* written and illustrated by Don Brown (1998). This book tells the story of astronaut Neil Armstrong, and it scientifically represents the full, third quarter, and the waning and waxing crescent moons.

The Moon and You, written by E. C. Krupp and illustrated by Robin Rector Krupp (1993), provides the third example of a children's book with scientifically accurate representations of the moon. All eight representative phases of the moon are included in the visual text of this book, which will be further elaborated on in the "Discussion" section.

Table 1. Findings for Selected Books

Author	Title	Phases Represented	Number Scientific	Number Alternative	Waxing Sequence	Waning Sequence
Asch, Frank	*Moonbear*	Full moon	4	0	Alternative	None
		Waning gibbous	0	1		
		Waning crescent	3	0		
Brown, Don	*One Giant Leap: The Story of Neil Armstrong*	Full moon	2	0	None	None
		Third quarter	2	0		
		Waning crescent	1	0		
		Waxing crescent	2	0		
Carle, Eric	*Papa, Please Get the Moon for Me*	Full moon	1	0	Alternative	Alternative
		Third quarter	1	0		
		Waning crescent	5	9		
		Waxing crescent	2	4		
		First quarter	1	0		
Ghazi, Suhaib	*Ramadan*	Full moon	3	0	Alternative	Alternative
		Waning gibbous	2	0		
		Waning crescent	3	2		
		Waxing crescent	3	3		
		First quarter	1	0		
		Waxing gibbous	2	0		
Krupp, E. C. & Krupp, R. R.	*The Moon and You*	Full moon	13	0	Scientific	Scientific
		Waning gibbous	9	0		
		Third quarter	3	0		
		Waning crescent	9	0		
		New moon	4	0		
		Waxing crescent	10	0		
		First quarter	3	0		
		Waxing gibbous	8	0		
Sis, Peter	*Starry Messenger*	Full moon	3	0	None	None
		Third quarter	4	0		
		Waxing crescent	1	0		
		First quarter	1	0		

While *Starry Messenger, One Giant Leap,* and *The Moon and You* all provide examples of picture books with scientifically acceptable illustrations, an example of an alternative representation in the visual text is *Ramadan*, written by Suhaib Hamid Ghazi (1996) and illustrated by Omar Rayyan. This striking picture book explains Ramadan and the lunar calendar. The visual text highlights the moon cycle, but the phases of the moon are inaccurate. These inaccuracies include overarticulating waning and waxing crescent moons.

The other two books, *Moonbear* (Asch, 1993) and *Papa, Please Get the Moon for Me* (Carle, 1986), included in Table 1, are further discussed in the "In-Depth Analyses" section.

Overall Findings

As noted, the researchers found inconsistencies in the visual text regarding scientific and alternative representations. As shown in Table 2, the results of the analysis revealed 615 scientific representations and 157 alternative representations.

Table 2. Frequencies of Specific Moon Phases in Illustrations

	Moon Books		Caldecott Books	
Lunar Phase	**Scientific**	**Non-Scientific**	**Scientific**	**Non-Scientific**
Full	277	53	69	0
Waning gibbous	28	16	0	0
Third quarter	18	3	4	0
Waning crescent	53	23	22	15
New	24	1	0	0
Waxing crescent	58	24	4	12
First quarter	20	6	1	0
Waxing gibbous	37	4	0	0

The full moon was the most commonly drawn shape. More than half of all the 772 moon illustrations were of the full moon (52%). About one quarter of the illustrations also included an image of a crescent moon (27%). Very few illustrations included any of the other phases—the new moon (3%), gibbous moon (11%), or quarter moon (7%). These results are consistent with previous research. In their pre-instruction drawings, children and adults drew a full moon and crescent moon more frequently than any other moon phases (Trundle et al., 2004, 2006, in press a, in press b).

It is interesting to note the difference in the number of illustrations of waning and waxing phases. Specifically, there were 182 illustrations of waning phases compared to 166 instances of waxing phases. This result, although of questionable statistical significance, is consistent with the results of earlier research with preservice teachers and fourth and eighth grade children who also drew more waning than waxing moons (Trundle et al., 2004, 2006, in press a).

In addition to omitting some observable shapes, the illustrations also included drawings of non-observable or non-scientific shapes, reflecting greater problems than simply omitting an observable shape. One-fifth of the 772 illustrations (20%) were non-scientific. Waxing and waning crescent phases were considered to be non-scientific if they were drawn as either over- or underarticulating. Non-scientific first and third quarter moons were drawn like a curved "half moon,"

consistent with a partial lunar eclipse. Similarly, non-scientific gibbous moons were drawn as a partial lunar eclipse. The most negative results were for the crescent and gibbous moons. Many of the crescent moon illustrations were non-scientific (32%), and nearly one-fourth of the gibbous moon illustrations were non-scientific (24%). All of the non-scientific drawings were consistent with the understanding of moon phases being caused by the earth's shadow, which only can be observed during a lunar eclipse. This finding is also consistent with research on preservice teachers' and fourth and eighth grade students' understanding of the shapes of moon phases (Trundle et al., 2002, 2004, 2006, in press a, in press b).

In-Depth Analyses

To further elaborate the overall results, an in-depth critical analysis of two books is provided. *Papa, Please Get the Moon for Me* (Carle, 1986) is described on the book jacket as a "first lesson in natural history, depicting the eternal cycle of the waxing and waning of the moon" and as "entertaining yet educationally sound." The visual text in this picture book completely misrepresents lunar phases, however. For example, the illustrations of the waxing and waning moon show crescents that change in size contrary to everyday observation. Other illustrations show the crescent moon as cutouts, with stars in the area where the unlit part of the moon should be.

The title page includes a pictorial representation of the sequences of moon phases from crescent, to quarter, to full, to quarter, and back to crescent. If the reader interprets the drawings from left to right, however, as is typically done, the proper sequence is reversed from a northern hemisphere perspective, with the waning phases preceding the full moon and the waxing phases following the full moon. Astonishingly, this book is included in a curriculum guide for elementary teachers wishing to teach about moon phases (Carratello, 1992). If teachers and parents use this book to teach moon phases, inaccurate conceptions may be instilled or reinforced.

Another example of children's literature that misrepresents the moon is *Moonbear* (Asch, 1993). In this popular children's book, the gibbous moon or as Asch calls it, "the three-quarter moon," is inaccurately drawn. The illustration does not represent any ordinary phase of the moon. Instead, it represents the partial phase of a lunar eclipse wherein the moon is partially within the Earth's shadow. Fourteen research studies on conceptual understandings of moon phases, involving over 2,600 people at all levels of schooling, reveal the most common alternative understanding is that moon phases are caused by the Earth's shadow (Baxter, 1989; Bisard, Aron, Francek, & Nelson, 1994; Callison & Wright, 1993; Cohen, 1982; Dai & Capie, 1990; Kuethe, 1963; Sadler, 1987; Schoon, 1992, 1995; Trundle et al., 2002, 2004, 2006, in press b; Zeilik et al., 1999). Asch's visual representations of the moon are likely to reinforce the common misunderstanding that lunar phases are related to shadows. As in Carle's book, Ash's visual text reverses the lunar phase sequence with the waning phases preceding the full moon. In regard to the written text, parts of *Moonbear* also contain mislabeled moon phases. Thus, this particular book has the potential to create inaccurate conceptions through both the written and visual texts.

Discussion: Addressing the Problem

Perhaps it seems churlish to complain about drawings of lunar phases in children's books; these books are literature, not science. It would also seem churlish to complain about Van Gogh's exaggerated stars in *Starry Night* or about scenes in *Star Trek* that could not actually take place. Yet, education strives, among other things, to convey an accurate understanding of the natural world. The results presented in this article clearly establish that illustrations in children's books reinforce inaccurate conceptions of lunar phases. Moreover, these illustrations most often reinforce the erroneous idea that lunar phases are related to the shadow of the Earth.

Given that many children's books include misrepresentations of the moon, how might teachers use children's literature to teach moon phases more accurately? There are several options. For one, teachers can continue to use these popular books, integrating them into inquiry-based instruction on moon phases. In this approach, students make regular observations of lunar phases, model the cause of moon phases, and compare their results with illustrations in the books. As a result, students not only understand lunar phases, they also gain practice in critical judgments of printed materials. *Physics by Inquiry* by Lillian McDermott (1996) suggests instructional activities for effective, research-based learning about lunar phases (Trundle et al., 2002, 2004, 2006, in press a, in press b). After gathering moon data and completing instruction, students can compare their observational data to the illustrations in books and look for differences. For example, do crescent moons really grow in size as if the moon were coming closer? Can you really see stars in the unlit portion of a crescent moon? Observant students will realize the answer to both questions is no, despite the illustrations in Carle's book.

Another option for teaching lunar phases is to use a scientifically accurate nonfiction book. One excellent example is *The Moon and You* (Krupp & Krupp, 1993). This book contains a wealth of information about moon phases, the moon's physical nature, its orbit, and eclipses. It also includes additional information about the moon, including moon legends and beliefs among various cultures through history. This particular book is a wonderful resource for teachers who wish to review the concepts of lunar phases. One word of caution, however: just because a book is classified as nonfiction does *not* guarantee content accuracy. Nonfiction books need to be carefully reviewed as well.

A third option for using children's books in teaching lunar phases is pairing together a fiction and a nonfiction book. Pairings will provide children with an opportunity to compare and contrast the two in terms of written and visual texts. Ultimately, experiences of observing the moon and recording its phases along with inquiry-based instructional techniques should accompany the use of the selected children's literature to ensure effective science instruction.

As discussed earlier, many adults have misunderstandings regarding the phases of the moon, so it is not surprising children also have misunderstandings. Even so, an understanding of this phenomenon can be achieved with proper instruction, and children's literature can be effectively integrated into classroom instruction. With careful observation of the sky, modeling, and some skillful guidance from their teachers, children can comprehend and appreciate this celestial cycle that is so much a part of human culture and experience.

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Appendix A. Coding Sheet for Moon Shapes and Patterns

First Author _____
Book Title _____
Researcher _____

Shapes of Moon	Scientific	Alternative	Label	Notes
Full moon				
Waning gibbous				
Third quarter				
Waning crescent				
New				
Waxing crescent				
First quarter				
Waxing gibbous				

Is a sequence of moon shapes represented? Yes No If Yes, complete the following:

Sequencing	Scientific	Alternative	Label	Notes
Moon wanes				
Moon waxes				
Phases included:	**Order**		**Label**	**Notes**
Full moon				
Waning gibbous				
Third quarter				
Waning crescent				
New				
Waxing crescent				
First quarter				
Waxing gibbous				