

Using Children's Literature to Teach Standard-Based Science Concepts in Early Years

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Abstract This paper discusses the benefits and limitations of using children's literature in introducing science concepts to young children. The manuscript also provides an overview of preschool science standards of 12 states and presents lists of appropriate children's literature suitable to use in teaching science concepts targeted in those preschool science standards.

Keywords Early childhood science education · Children's literature · Preschool science content standards · Misconceptions

Introduction

Science education in early childhood is of great importance to many aspects of children's cognitive and social development (Eshach 2003; Eshach and Fried 2005; Kallery and Psillos 2001). Although science is emphasized as important in early childhood, teachers find it challenging to teach science to young children for various reasons (Appleton and Kindt 1999, 2002). Using children's literature to introduce science concepts to young children offers a solution because of teachers' familiarity with this instructional tool.

There seems to be a growing consensus among researchers that children's literature including picture books, fiction and nonfiction books can be used as instructional tools to teach science (Monhardt and Monhardt 2006; Morrow et al. 1997; Saul and Dieckman 2005;

Zeece 1999) and foster interest in and positive attitudes toward learning science in early years (Broemmel and Rearden 2006; Castle and Needham 2007; Coskie 2006). Zeece (1999) argued that science-based literature is a key part of an environment that supports young children's development of scientific concepts. Well-written and developmentally appropriate literature not only provides content knowledge and fosters science process skills; it also awakens children's curiosity and offers opportunities for inquiry. Literature supports children's interest in learning science by presenting content knowledge in narrative form to help children understand difficult science concepts (Morrow et al. 1997). Using children's literature to teach science makes learning more relevant by putting the science concepts and process skills in a context that is more meaningful for children (Henriques and Chidsey 1997). Children's literature supports children's science learning by offering opportunities to make observations, raise questions, and reach conclusions from evidence in an environment that is meaningful (Castle and Needham 2007; Monhardt and Monhardt 2006; Pringle and Lamme 2005).

Although there is a limited number of research studies that investigated the effect of using children's literature to teach science, evidence provided by the existing studies suggests that children's literature can be used as an effective instructional tool to teach science concepts to young children (Bricker 2005; Castle and Needham 2007; Morrow et al. 1997). Therefore, many researchers recommend lists of books, criteria to choose among available books, and pedagogical approaches to using books to teach several science concepts (Pringle and Lamme 2005; Wells and Zeece 2007). On the other hand, researchers have identified several limitations including: misconceptions embedded in texts (Kazemek et al. 2004), inaccurate illustrations (Trundle and Troland 2005), fantasy (Broemmel and

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Rearden 2006) and anthropomorphism (Gomez-Zweip and Straits 2006) in children's books that are widely used in early childhood classrooms.

In their review of science-based picture books, Broemmel and Rearden (2006) found that several books contained some aspect of fantasy. They recommended that teachers discuss fantasy aspects versus science concepts included in these books to clarify the differences. Although anthropomorphism might lead children to think that animals or inanimate objects can talk like humans, many researchers seem to agree that it should not be a serious problem if students are encouraged to ask questions and think about the content (Gomez-Zweip and Straits 2006; Pringle and Lamme 2005). Thus, these researchers suggested that anthropomorphism was not a specific or substantial problem with science learning. However, the language and illustrations used in children's literature, such as implying that humans are not an animal species or illustrations that depict the moon only during the nighttime, might present a source of misconceptions.

Misconceptions embedded in text and inaccurate illustrations seem to present the most serious obstacles to learning scientific concepts. Kazemek et al. (2004) investigated how children's literature influences the way children think about and understand their natural world in a study conducted with six children and their parents. These researchers specifically focused on children's ideas about the moon and found that children's understanding of the moon is influenced by their experience with children's literature (Kazemek et al. 2004). They argued that children's literature can influence children to think that the moon gets smaller by shrinking in size, to conceive that the moon is a place very similar to earth, and to attribute human characteristics to the moon.

Similarly, Trundle and Troland (2005) and Trundle et al. (2008) demonstrated that children's books can be a source of children's misconceptions about the moon. The researchers evaluated 79 children's books that focused on the moon and found that many books misrepresented the moon, with non-observable moon shapes and inaccurate moon phase sequences. Many books also reinforce the common misconception that moon phases are caused by the earth's shadow. Trundle and colleagues (Trundle and Sackes 2008; Trundle and Troland 2005) offered several inquiry-based thinking questions that teachers can use to raise children's awareness about misconceptions. Owens (2003) also reported several misconceptions embedded in illustrations and language in children's books and recommended several strategies to address problems with the books. Recommendations included reading aloud nonfiction and fiction books on the same subjects and modeling and inviting students to ask comparative questions about the content of the books to prevent misconceptions from forming.

Rish's (2003) investigation of a teacher's use of children's literature in a first grade science classroom showed that children's understanding and misconceptions presented in the books were not always addressed by the teachers. She found that children in her study exhibited several misconceptions. Therefore, both Owens's (2003) and Trundle and Troland (2005) suggestions seem crucial in using children's literature to teach science. Ford (2006) examined 44 randomly chosen trade books from a public library and observed that many of the examined books misrepresented the scientists and scientific practices. Ford suggested that an oversimplification of science content and a limited scientific background of the authors might be the sources of numerous misconceptions in children's books. Pringle and Lamme (2005) also argued that the science background of author may be important in writing and illustrating books about science content.

Pappas (2006, p. 242) argued that "learning science is also learning its linguistic registers". Therefore, informational books can be the best choice to foster the development of children's scientific concepts as they are written in a format of scientific discourse. Hybrid books that present the scientific concepts in a narrative format might not accomplish the task of teaching the language of science to children. However, some researchers believe that presenting content knowledge in a narrative form helps children understand difficult science concepts (Morrow et al. 1997). Since children at early ages think in a narrative format (Kazemek et al. 2004), introducing scientific concepts in a language they are familiar with seems reasonable. Furthermore, many researchers agree with the view that using picture books, if they are carefully chosen, to teach science concepts to young children can be an effective pedagogical approach, and this approach has become widely used by the practitioners (Morrow et al. 1997; Saul and Dieckman 2005; Spencer and Guillaume 2006).

Purpose of the Study

The use of children's literature to teach science concepts has gained popularity with the increased emphasis on standardized testing (Saul and Dieckman 2005). A problem remains, however, with finding appropriate literature to use in classrooms. The aim of this study, therefore, is to identify appropriate children's literature which is suitable to use in the teaching of science concepts targeted in preschool standards. In the current study we focused on picture books, fiction and nonfiction, which are written to include children between ages 3 and 5 years (see Tables 1, 2, 3). No genre of literature was excluded from this study. Rather, we focused the content identified in the preschool

Table 1 Physical science concepts related books

Author	Title	Science concept	Application	Limitation
Asch, Frank	<i>Moonbear's Shadow</i>	Shadows	<i>Inquiry:</i> Look at the position of the light source and direction of shadow. Compare actual observations at noon to illustration <i>Age level:</i> Ages 4–5 years	<i>Content Misconception:</i> Very few places have no shadows at noon—when the sun is directly overhead.
Bulla, Clyde Robert	<i>What Makes a Shadow</i>	Shadow, light, the way light interact with different materials, the relationship with shadow of the objects and the light source	<i>Inquiry:</i> Explore how light interacts with different materials (paper towel vs. book). Which objects have darker shadow? Describe the relationship with shadows and the light source. What affects the size of the shadow? <i>Age level:</i> Ages 3–5 years	–
Dorros, Arthur	<i>Me and My Shadow</i>	Light and shadow, day and night, reflection	<i>Inquiry:</i> Use to teach about light and shadow, reflection. Activities such as drawing shadows of the objects, producing shadow of the objects with flashlight <i>Advanced:</i> Use with children who have some knowledge base in the topic <i>Age level:</i> Ages 3–5 years	<i>Advanced:</i> Includes advanced concepts, such as cause of the moon phases, day and night
Gordon, Sharon	<i>Just the Opposite</i>	Properties of matter	<i>Inquiry:</i> Use to focus on one property of matter (hard/soft) <i>Age level:</i> Age 5 years	<i>Other:</i> Use as part of a larger exploration of properties of matter.
Graham, Bob	<i>Pig's Wild Cart Ride: An Early Learner Book About Motion</i>	Motion	<i>Inquiry:</i> Use to teach about what makes objects move, what makes them move faster, and what makes them stop <i>Age level:</i> Ages 4–5 years	–
Narahashi, Keiko.	<i>I Have a Friend</i>	Shadows	<i>Introductory text:</i> Use to introduce and explore shadows <i>Inquiry:</i> A good book to play around with shadows; good for asking questions about shadows <i>Age level:</i> Ages 4–5 years	<i>Text:</i> Note that the word shadow is never used. Teacher will need to scaffold <i>Illustrations:</i> Keep in mind that the illustrations do not show light sources <i>Content:</i> A little personification; also does not directly address time of day.
Warbrick, Sarah	<i>What is Bendy?</i>	Properties of matter, bending	<i>Inquiry:</i> Use to focus on one property of matter (malleability) Children can be asked to predict the objects that are bendable in the class after reading the book. Last page can be used to promote discussion <i>Age level:</i> Ages 4–5 years	<i>Other:</i> Use as part of a larger exploration of properties of matter <i>Note:</i> Five other books in this series are also appropriate introducing properties of matter.

science standards and books that might be appropriate for preschool children.

Methodology

To identify appropriate children's literature which is suitable to use in the teaching science concepts in preschool classrooms, the academic content standards of 50 states

were reviewed, and states which included preschool standards were identified. States with preschool science content standards were selected for deeper analysis of common content areas and themes. After identifying common content areas and themes across states standards, children's literature which target science concepts in common themes was identified using a popular search engine and searching catalogs of online book stores. About 73 children's books were identified and examined for the current study.

Table 2 Earth and space science concepts related books

Author	Title	Science concept	Application	Limitation
Anderson, Sara	<i>Noisy City Night</i>	Objects in night sky, sounds sight.	<i>Inquiry:</i> Observe objects in the night sky. Observe sounds, sight and activities of night. Compare to <i>Noisy City Day</i> <i>Age level:</i> Ages 3–5 years	<i>Content:</i> Limited to one night. Content: Can not see change in moon from night to night.
Anderson, Sara	<i>Noisy City Day</i>	Observing objects in the day sky, what we see, hear and do during day.	<i>Inquiry:</i> Observe objects in day sky. Observe sounds, sights and activities of day. Compare to <i>Noisy City Night</i> book <i>Age level:</i> Ages 3–5 years	<i>Content:</i> Limited to one day and the moon is not in the sky.
Carle, Eric	<i>Little Cloud</i>	Weather, cloud, recognize the relationship between clouds and rain	<i>Inquiry:</i> Explore the relationship between clouds and rain (last page) <i>Age level:</i> Ages 4–5 years	<i>Content:</i> Includes anthropomorphizing clouds <i>Illustrations:</i> Includes fantastic shapes <i>Content misconception:</i> Clouds do not get darker while they rain
Christian, Peggy	<i>If You Find a Rock</i>	Rocks (color, texture, layer), different types of rocks, properties of different types of rocks and their uses	<i>Inquiry:</i> Photos can be used for observations of properties of rocks and uses of rocks <i>Age level:</i> Ages 4–5 years	–
Fletcher, Ralph	<i>Twilight Comes Twice</i>	Observable characteristics of twilight, objects in twilight sky	<i>Inquiry:</i> Observe objects in twilight sky. Observe sounds, sights, activities of twilight sky. Compare to day and night. Compare moon illustrations with actual observations <i>Age level:</i> Ages 4–5 years	–
Fowler, Allan	<i>Can You See the Wind?</i>	What causes wind. How people use wind. How wind affect people. Observation of wind speed.	<i>Inquiry:</i> Use photographs to make observations of -how wind affects people, -how people use wind, -how we can observe relative wind speeds <i>Advanced:</i> Content useful for more advanced preschool exploration <i>Teacher resource:</i> Science background information provided for teachers <i>Age level:</i> Ages 4–5 years	<i>Advanced:</i> Includes concepts beyond PreK like the cause of wind. <i>Other:</i> Small size of book might make large group observation difficult.
Rylant, Cynthia	<i>Night in the Country</i>	Sounds of night, differences in day and night.	<i>Inquiry:</i> Use for observations of day and night. What do we see and hear at night? Use in conjunction with <i>Noisy City Night</i> <i>Age level:</i> Ages 4–5 years	–
Spier, Peter	<i>Rain</i>	How weather affects personal activities	<i>Inquiry:</i> Use illustrations used to make observations of how rain affects people, plants & animals. Compare rainy day pictures to Sunny day pictures. How are they different? <i>Age level:</i> Ages 4–5 years	<i>Content:</i> Limited to one concept.
Winter, Jeanette	<i>Elsina's Clouds</i>	Clouds and rain, patterns in rain, rainy and dry seasons, how weather affects humans, plants, animals	<i>Inquiry:</i> Explore how too little rain affects humans, plants, animals. Also can make cultural connections to other cultures- what people do when too little rain (rain dances) too much rain <i>Age level:</i> Ages 4–5 years	–

As previously mentioned, picture books, both fiction and nonfiction, were included in this study. We included both genres because previous studies (Trundle and Troland

2005; Trundle et al. 2008) have identified some fiction books as appropriate for use in science learning, nonfiction books tended to be too limited in terms of the content

Table 3 Life science concepts related books

Author	Title	Science concept	Application	Limitation
Glaser, Linda	<i>Wonderful Worms</i>	Earthworms, soil	<i>Inquiry:</i> Use for inquiry about a simple animal and an animal not typically visible but one that's easy to find <i>Age level:</i> Ages 4–5 years	–
Laytan, Neal	<i>Smile if You're Human</i>	Animal families, compare different animals, compare different animals to the humans	<i>Introductory text:</i> Can be used to teach about difference between animals and humans <i>Inquiry:</i> Venn diagrams can be used to describe similarities and difference between the animals in the story <i>Age level:</i> Ages 3–5 years	–
Simon, Norma	<i>All Kinds of Families</i>	Families, observe and describe similarities and differences in the members within the same family	<i>Introductory text:</i> Can be used to teach about similarities and differences between family members <i>Inquiry:</i> Compare illustrations of babies to mothers. How are they alike? <i>Age level:</i> Ages 4–5 years	<i>Content:</i> Science content is not explicit and the animals are anthropomorphized. <i>Illustrations:</i> Can not see much of body structures of animals <i>Illustrations:</i> Consider supplementing with actual photographs of animals.
Sneed B.	<i>Animal Dads</i>	Animal behaviors, animal families, similarities and differences within animal families, dads and babies.	<i>Inquiry:</i> Examine illustrations. How are babies like/different from Dads? <i>Age level:</i> Ages 4–5 years	<i>Content:</i> The science content is not explicit <i>Illustrations:</i> Consider supplementing with actual photographs of animals.
Sweaney, Joan	<i>Me and My Family Tree</i>	Families, human families and family trees	<i>Inquiry:</i> Look at families. How are they similar and how are they different? <i>Age level:</i> Ages 4–5 years	<i>Content:</i> No explicit discussion of similarities and differences among families/family members, but concept could be introduced or reinforced with a discussion.

available for preschool, many nonfiction books were too advanced for young children, and we wanted to include books that are generally readily available to preschool teachers.

Aligning children's literature with common themes from standards was followed by analysis of identified children's books for content accuracy including illustrations and text. The books were independently coded and analyzed using a coding sheet designed for the study. The coding sheet facilitated analysis and helped standardize coding between the researchers (Coffey and Atkinson 1996). The last step was describing the strengths and limitations of each book and developing the list of appropriate children's literature to teach science concepts in preschool classrooms.

Although many characteristics of young learners (e.g., gender, English proficiency) may impact their interest and understanding of particular children's literature, our focus was on identifying and analyzing how books for young children present science concepts and on giving guidelines to teachers for their use. We believe this will enable teachers to find books that are scientifically sound and coherent with preschool science standards and to consider their appropriateness for the needs of their students.

Common Themes from Preschool Science Standards

State science content standards were obtained from each state's department of education website. There were 17 states with preschool-kindergarten science content standards, however, only 12 states had separate academic science content standards for just the preschool level.¹ Preschool academic science content standards of those 12 states were examined and three common content areas across states were identified: physical science, earth and space science, and life science. Within each common content area several common themes across states were also identified.

Six common themes for physical science were identified across the 12 states: (1) Physical properties of objects and materials such as solid–liquid and hard–soft was the most common theme across the states (all 12 states); (2) classification of objects and materials based on their qualities

¹ District of Columbia, Maryland, Mississippi, Montana, Ohio, Oklahoma, Rhode Island, South Dakota, Tennessee, Texas, West Virginia, Virginia.

such as weight and shape (9 states); (3) movement of the objects (6 states); (4) sound; (5) light; and (6) physical changes.

For the earth and space science content area, four common themes were identified: (1) weather (8 states); (2) day and night (4 states); (3) earth materials (3 states); and (4) season (3 states).

Five common themes for life science, the most emphasized content area in preschool science content standards, were identified: (1) life cycle of plants and animals (9 states); (2) plant and animal habitats (8 states); (3) classification of plants and animals (7 states); (4) common needs of plants and animals (6 states); and (5) heredity (5 states).

Results for Recommended Children's Books

Children's literature which aligned with the common themes from across the preschool science content standards were identified using a popular search engine and searching catalogs of online book stores. The identification process of the children's literature yielded a total of 73 books. A coding sheet was developed to organize and standardize the review process among the researchers. The coding sheet included the bibliographical information of the book, information about the targeted science concepts, accuracy of the text and picture, and strengths and limitations of the book. These books were independently examined by the researchers.

Books Related to Physical Science Concepts

Of the 73 books, 32 books were related to physical science topics. These 32 books were reviewed for content and illustration accuracy, developmental appropriateness, and possible misconceptions communicated in text or on illustrations. Of the 32 physical science related children's books 12 books were identified as appropriate to use in preschool settings. Four books included light, shadow and reflection concepts, one book included motion concepts, and the remaining seven books focused on properties of matter. The characteristics of recommended books and suggested ways of using them are presented in Table 1.

About 20 physical science related books were deemed inappropriate to use with preschool children for several reasons. Five books contained misconceptions (such as that people can see in the dark), 15 books included content and vocabulary that was too advanced for preschoolers. Nine books contained inaccurate scientific statements and five books had inaccurate illustrations (such as shadows positioned in a backward or wrong direction relative to the light source, the sun). Seven books had other minor issues such as small size with no larger size available, illustration-text

mismatch, and anthropomorphism (e.g., personification of sun and shadows including the sun sleeping).

Books Related to Earth and Space Science Concepts

Of the 73 children's books, 25 books included earth and space science concepts. These 25 books were reviewed for content and illustration accuracy, developmental appropriateness, and possible misconceptions communicated in text or on illustrations. The reviews identified nine books that were appropriate for use with preschool children. Four of these books included weather-related concepts, one book focused on earth materials, and the remaining four books included day, night, or sky concepts. The characteristics of the recommended books for earth and space science concepts and suggested ways of using them are presented in Table 2.

About 16 reviewed books were not recommended for use in preschool classrooms. Three books had misconceptions (such as unobservable moon phases, moon does not move). Ten books included content and vocabulary that was too advanced for preschool children. Three books had inaccurate text and four books had inaccurate illustrations (misleading color and shapes for clouds). Four books had other minor issues such their small size, illustration-text mismatch, and anthropomorphism (personification of the moon and animals).

Books Related to Life Science Concepts

Of the 73 children's books reviewed for this study, 16 books included life science concepts. An analysis of these 16 books for content and illustration accuracy, developmental appropriateness, and possible misconceptions communicated in text or on illustrations resulted in the identification of five books, which are recommended for use with preschoolers. Four books included similarities and differences between and within animal and human families and one book focused on earthworms. The characteristics of the recommended books on life science concepts and suggested ways of using them are presented in Table 3.

About 11 books were eliminated from the life science concepts books list. Three books had misconceptions (such as fish not shown in a natural habitat but rather a tank, all trees have flowers). Eight books included content and vocabulary that was too advanced for preschool children. Four books had inaccurate text (inappropriate analogy, e.g., tree trunk supports like human's leg supports a person), and one book had inaccurate illustrations (vague body structures of animals). Four books had other minor issues such small size, availability, and anthropomorphism (e.g., animal mothers love their babies like human mothers do).

Discussion

We had difficulty identifying children's book that focus on physical science concepts and had to make extra effort to find children's books that include physical science concepts. Previous studies reported that physical science and earth science related children books are underrepresented relative to life science concepts related books (Ford 2004, 2006). Overrepresentation of life science concepts might be due to preschool teachers' reported confidence in teaching life science related concepts (Akerson 2004; Appleton 1992). The demand of preschool teachers for more life science books might encourage publishers to focus on producing more life science related books compared to other content areas. Conversely, the greater availability of life science related children books might cause preschool teachers to feel more comfortable teaching life science concepts.

Many books reviewed in this study included misconceptions, anthropomorphism, and inaccurate illustrations. However, the books that were written under science consultants were less likely to contain misconceptions and inaccurate illustrations. In selecting children's books, teachers should consider the science background of the author and illustrator (Pringle and Lamme 2005) and if a science consultant was used.

Teachers should be cautious in using children books with misconceptions and inaccurate illustrations. Although books that are free of misconceptions and inaccurate illustrations are preferable, teachers can turn children's books with such limitations into learning opportunities by discussing the differences between the actual and the represented events in such books. Examples of using children's books that include misconceptions and inaccurate illustrations can be found in other studies (Trundle and Troland 2005; Trundle and Sackes 2008).

Our review of the children's literature revealed that this medium offers a unique opportunity for introducing science concepts in the early years as well as for curriculum integration of literacy and science. Therefore, exploring the ways that children's literature can be used in early childhood classrooms presents important implications for early childhood teachers.

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