Using Children’s Picturebooks to Develop Critical Thinking Skills and Science Practices in Grades 3rd-5th

Emily Cleveland
University of Wyoming

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Using Children's Picturebooks to Develop Critical Thinking Skills and Science Practices in Grades 3rd-5th

By

Emily Cleveland

M.S., University of Wyoming, 2015

Plan B Project

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Laramie, Wyoming

Masters Committee:
Dr. Kate Welsh, Co-chair
Dr. Tammy Mielke, Co-chair
Dr. Jeff Lockwood, University of Wyoming
Dr. Margaret Hudson, Principal, University of Wyoming Laboratory School
Abstract

Science literacy among US adults is extremely low and interest in science related careers is declining. In an era where environmental challenges pose a significant threat to humanity, it is imperative that the generation of students who grow to inherit this problem be scientifically literate and interested in science issues. By capitalizing on positive science attitudes in primary grades, teachers can alter this trend by developing critical thinking skills and science practices in order to build a foundation of knowledge and skills for subsequent secondary science learning. Picturebooks can provide relevance and context for meaningful science learning; develop visual and text literacy, and present science as an approachable, interesting discipline. This project is intended to explain the benefits and justifications for using picturebooks to promote critical thinking and development of science practices and how to select appropriate books for classroom use. Accompanying this project is an analysis of ten exemplary picturebooks for teaching science. A template is used to evaluate these ten books and explain the qualities that make each book an effective teaching tool. In addition, examples of classroom activities that meet Next Generation Science Standards Disciplinary Core Ideas, Science and Engineering Practices, Crosscutting Concepts, and Common Core Informational Literacy Standards are presented. It is intended that this project will serve as a useful resource for educators looking to enrich science learning for students in 3rd through 5th grade.
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Chapter 1
Introduction

National surveys indicate that science knowledge among US adults is alarmingly low and interest in science related professions has been declining (NRC, 2012; Wells & Zeece, 2007). Miller (2004) defines scientific literacy as a vocabulary of scientific terms and constructs and an understanding of the nature of scientific inquiry. Studies indicate that less than 20% of US citizens are scientifically literate (Miller, 2004). In addition, while the number of science PhD graduates in the US has declined, PhD graduates abroad have increased over the same time period (National Bureau of Economic Research, 2004). Research also shows that by high school, 80% of students are disinterested in science career choices and there is fear that the US will lose its competitive edge in the global economy if interest in science professions continues to decrease (Coyle, 2005).

Reduced levels of interest in science not only have economic implications but also environmental and social implications. Wells and Zeece (2007) state, “The deficiency of environmental knowledge, especially in this time when challenging environmental choices arise, is a ‘wake-up call to the environmental education community, to community leaders, and to influential specialists ranging from physicians to weathercasters’” (Coyle, 2005, p. ii). It is imperative that the generation of students who grow to inherit the current environmental challenges be scientifically literate and interested in science issues.

Researchers argue that science education should begin in the early elementary years in order to build cognitive and social development and to create outlooks about science that can influence lifelong attitudes and behaviors (Kettler, 2014;
Illustrated children’s literature is a logical tool for teaching science in early elementary education because it is familiar, engaging, and can create multiple meanings with a blend of text and illustration (Sackes et al., 2009; Wason-Ellam, 2010; Manifold, 2000). Connecting prior knowledge, identifying key concepts, synthesizing information, making inferences, and making predictions are elements of both literacy and scientific practices which are important to develop in elementary years in order to provide a foundation for future science learning (Ford, 2006; Mantzicopoulos & Patrick, 2011). In addition, children’s literature can provide context for learning, which is positively associated with student motivation to learn and study (Carr, Buchannan, Wentz, Weiss, & Brant, 2001; Monhardt & Monhardt, 2006; Ward, 2005). There is also evidence that learning is enriched when students are enjoying themselves (Reisberg, 2008). Using illustrated children’s books as a tool for teaching science could deepen access to complex subjects and create positive attitudes about science and science careers for learners.

Using illustrated children’s books to frame science content lessons can also develop students’ visual analytic skills while teaching them to consider science an approachable, interesting discipline open to all types of learners. Donovan and Smolkin (2002) argue that genre, content, and visual features enhance science instruction and encourage young readers’ interest in science-related topics. Visual literacy is not only important for science instruction but also for navigating today’s image saturated society (Palmer & Stewart, 2005). Therefore visual literacy should be a fundamental piece of classroom instruction for the benefit of all disciplines.
Purpose and Background of Project

As a visual learner I have always been drawn to illustrated books. Several books from my childhood provided formative experiences that have shaped my social, scientific, and environmental perspectives today. As an artist, it is the illustrations that stand out in my memory. I remember the stories as told through the pictures. I loved pouring over the illustrations, considering the information they contained, the different styles and techniques, and how they communicated a feeling to enhance a story. Analyzing the information contained in illustrations and considering how they explained what the text could not fascinated me. To this day, I can more easily extract information from a picture, diagram, or other visual data, and it became a useful skill when I found myself studying science in college and graduate school. However, this was not always the case. As a victim of rote memorization science instruction, I remember feeling that science was difficult, dull, and that I was not good at it. Observation, creativity, and the visual aspects of science were pushed to the wayside as memorization, and regurgitation took precedence.

As a field educator at the Teton Science School, I found storytelling to be a successful tool for teaching students about new and complex subjects such as geology or experimental design. Student engagement and comprehension increased as a result of rooting lessons in a story. These experiences prompted me to think about the use of storytelling in traditional classroom environments. There is a large body of literature on the subject of using children’s books to teach everything from social studies to mathematics. The National Council for Teachers of Mathematics specifically calls for the use of literature as a tool for teaching mathematics (National Council of Teachers of
Mathematics, 2000). Many of the justifications for using children’s illustrated storybooks in math classrooms also apply to science classrooms.

This Plan B project is intended to consolidate available literature about picturebooks and their ability to promote critical thinking and science practices in 3rd through 5th grade. I will address the challenges of using children’s literature in a science context, including a discussion of the negative perception that illustrated children’s literature engenders misconceptions and stereotypes (Sackes et al., 2009; Ford, 2006), and explain how to select and use an appropriate text for the classroom. Accompanying this literature review is a list of children’s books suitable for science teaching with descriptions of how they can be utilized to meet the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) and the Common Core English Language Arts Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). A bibliography of suitable children’s literature for science instruction is also included (Appendix B). It is intended that this project will be a useful resource for elementary science educators looking to enrich student learning. By using children’s literature to engage students in learning science at an early age, teachers and parents can help to build a foundation of knowledge and critical thinking skills for students to build upon as they progress through their continuing education.

Definitions of Important Terms

Picture Books/ Picturebooks

For the purpose of this project “picture books” will refer to both fiction and nonfiction illustrated children’s literature. The terms “picture book”, and “picturebook” are terms that are used interchangeably throughout this paper to describe the presentation
of information through the integration of verbal and visual communication. Wolfenbarger and Sipe (2007) explain that “the compound word ‘picturebook’ recognizes the union of text and art that results in something beyond what each form separately contributes” (p. 273). Bishop and Hickman (1992) similarly define picture books as texts that use “both pictures and text [to] work interdependently to tell a story” (Carr et al., 2001). This fusion of text and art allow the reader to integrate his or her own experiences and interpretations into each element to create a unique experience (Wolfenbarger and Sipe, 2007). Both fiction and nonfiction picture books provide opportunity for learning visually through a combination of pictures and words which develop observation skills (Carr et al., 2001; Comber, Cremin, & Hall, 2013; Manifold, 2000; Pringle & Lamme, 2005).

The standard format for a picture book is 32 pages with relatively brief text and pictures on each page or double page spread (Bishop & Hickman, 1992). There are increasing examples of non-fiction picture books that follow this format but layout tends to vary more in nonfiction than in fiction. Fiction books are also referred to as “storybooks” or “narrative texts” while nonfiction books are often called “informational texts.” However, the recent rise in popularity of nonfiction books due to the Common Core focus on informational text literacy has resulted in a surge of new literature. Many of these books are narrative informational texts that incorporate artistic illustrations, accurate science content, a narrative plot, and other informational features such as scientific diagrams, glossaries, or appendixes. The books chosen for this project are primarily narrative informational texts as these hybrids often contain the best of both traditional fiction and nonfiction genres. The term ‘trade book’ refers to books of any genre that are created for the commercial market.
Critical Thinking

Critical thinking is a broadly used term in a variety of disciplines. For the scope of this review, critical thinking is defined as self regulatory judgment which results in evidence-based interpretation, analysis, evaluation, and inference as well as explanation of the considerations upon which judgment is based (Kettler, 2014). Self-directed, and self-corrective thinking is an important aspect of developing metacognitive skills for children (Helterbran & Strahler, 2013). In addition, this definition of critical thinking entails effective communication and problem-solving abilities that can help students begin to overcome inherent egocentrism and sociocentrism (Helterbran & Strahler, 2013). It is important to expose children to different perspectives and ideas and habituate them with the practice of reflecting on information to create their own explanations and understandings. In this manner, students can build the necessary skills to think beyond themselves and their comfort zones to become investigators of the world around them.

These are extremely important skills to foster in education. The Educate America Act of 1994 described critical thinking as “an essential characteristic of quality education” and a necessary 21st century skill (Kettler, 2014). Twenty years later the importance of critical thinking is still a point of emphasis in developing science curriculum. With proper selection, facilitation, questioning strategies, and extension activities, teachers can use a familiar classroom tool to build a foundation of skills that will benefit students in a variety of disciplines in their continued education.

Standards and Science Practices

There are many parallels between critical thinking and scientific inquiry; in fact the National Science Education Standards describe inquiry as requiring “identification of
assumptions, use of critical and logical thinking, and explanations” (National Research Council, 1996, p. 23). The National Research Council also states that “students cannot fully understand scientific and engineering ideas without fully engaging in the practices of inquiry and the discourses by which such ideas are developed and refined” (NRC, 2012; p. 218). Almost two decades ago the National Science Education Standards were published with a call for revolutionary change in the way science was taught. The standards focused on developing student knowledge and understanding of scientific ideas with an emphasis on practicing science. Scientific ‘inquiry’ became the descriptor for this new approach to science teaching.

Education standards have begun to shift but the goals remain the same. The term inquiry has come to be interpreted in so many different ways that in order to clarify the intent of science inquiry in the classroom, NGSS use the term science “practices” instead of “skills” or “inquiry” (NGSS Lead States, 2013). The Framework for K-12 Science Education upon which the NGSS are built, emphasize that students must learn the disciplinary core ideas in the context of the eight science and engineering practices and use crosscutting concepts to bridge disciplinary boundaries and create a coherent, scientifically based view of the world (National Research Council, 2012). By integrating content with practice, students are more likely to understand the true nature of science. For the scope of this review, science practices will refer to the process of active learning where students use knowledge and understanding of science content to develop questions, collect data, design solutions, and create arguments from evidence (National Research Council, 2000).
Thirteen states have adopted NGSS, and with the signing of a new bill on March 2nd of 2015 that opens up the possibility of adopting NGSS, Wyoming may soon follow. Wyoming currently follows Common Core standards, which embed science within literacy until middle school. Informational literacy is an important component of science education (see Chapter Two). However, by delaying the introduction of science as an independent discipline in elementary school, students may develop misconceptions about science and be unfamiliar with science practices at a crucial developmental stage. While many teachers and schools choose to go beyond what the Common Core standards call for, there is a chance that some students may not have engaged in science practices by the time they reach middle school. The ability to evaluate knowledge in relation to new information or different frameworks and to modify ideas accordingly is a key scientific practice that can help students learn new and related material more effectively and is an important transferable skill (Michaels, Shouse, & Schweingruber, 2008). The combination of Common Core informational literacy standards with NGSS content and practice standards can more effectively guide elementary science instruction. Therefore the books analyzed in this project are evaluated in terms of both NGSS and Common Core standards.
Chapter 2
Literature Review

For the purpose of this study, peer-reviewed literature was examined regarding elements of narratology, visual theory, critical thinking, pedagogical theory, cognitive science, nonfiction, and fiction in order to determine the resources currently available that support the integration and use science and literature. Arguments are presented for the benefits of incorporating picturebooks in the science classroom, the challenges associated with their use, how to select appropriate books for the classroom, and how to use them appropriately.

The Benefits of Using Children’s Literature in the Science Classroom

Positive Science Attitudes

Children are capable of learning about science as early as Kindergarten (Mantzicopoulos, et al, 2009; Michaels et al., 2008). The more early opportunities children have to participate in science experiences, the more likely they are to build strong foundations in science and develop positive attitudes about science as a discipline (Barclay, Benelli, & Schoon, 2012; Mantzicopoulos & Patrick, 2011). The development of positive science attitudes is especially important for boosting interest in science. There is a perception that physical, earth and space, engineering, technology, and applied sciences are unaesthetic and less connected to ordinary people, and that they are difficult and dull to study (Ford, 2006). However a study by Baram-Tsabari and Yarden (2005) found that children under the age of eight were twice as interested in physics as older children. Mantzicopoulos and Patrick (2010) state:
Building young children’s knowledge and interest in physical science before they apparently lose interest and begin to view it as more difficult than other areas of science may help to address the widespread concern that too few American students, especially girls and racial or ethnic minority students, are entering STEM disciplines. (p. 436)

The National Science Foundation Advisory Committee similarly suggests that environmental education should be incorporated into education at all levels including early childhood in order to increase interest in the sciences (Coyle, 2005). Mantzicopoulos et al. (2009) agree:

Science instruction should begin by the early school years if children are to develop, not only the requisite skills and knowledge for careers that involve science, but the view that engaging in science is a legitimate part of who they are and who they may become. (p. 364)

By engaging students in science at a younger age, students may be more interested in science disciplines when they reach secondary school, which could boost interest in science careers. However after the passage of the No Child Left Behind Act (2001) the amount of weekly minutes devoted to science instruction in elementary schools was decreased by 33% in order to focus on more heavily tested elementary subjects such as reading and math (Hug, 2010). This lack of emphasis on science education in primary education could suggest to students that science is less important than other academic subjects (Mantzicopoulos et al., 2009). Therefore it is important to emphasize science in elementary school and frame it as an important subject in order to develop positive science attitudes.
The integration of illustrations and text also help to develop positive science attitudes while making content more available to visual learners (Carr et al., 2001; Pringle & Lamme, 2005). This is important because visual learners can often fall behind or decide that they are “not good at science”. Illustrations can communicate content in a more accessible way and can provide clues for unfamiliar words (Carr et al., 2001). Presenting science visually can encourage learners to pursue science interests because it can reduce resentment and frustration in the learning process and can build a foundation of knowledge for secondary science which keeps these students from falling behind their peers (Carr et al., 2001).

**Providing Context**

Teachers are often challenged to integrate science into elementary education because it is often decontextualized, and presented as fragmented skills and knowledge that lack relevance for children (Mantzicopoulos et al., 2009). Relevance is an extremely important component of successful instruction that is positively associated with student motivation to study and learn (Monhardt & Monhardt, 2006; Price & Lennon, 2009; Wells & Zeece, 2007). Picture books can provide missing relevance and context in order to bridge the gap between elementary students and meaningful science education. Carr et al. (2001) state, “A story is a strong teaching tool that offers a situated perspective for knowledge, thinking, and learning. Add striking illustrations, and picture books become a powerful medium for building understanding” (p. 147). Engaging illustrations, depictions of other children, and characters that draw the reader in can all create a meaningful foundation for science information. Therefore, picturebooks can be a powerful means of creating knowledge.
Picturebooks are a central piece of early childhood education, which gives older students familiarity with them as tools for understanding. Picturebooks are commonly used to develop a child’s understanding of morality, and to tackle ethical issues (McCall & Ford, 2012). Constructivist developmental theory suggests that children actively construct their understanding of the world and picturebooks are a formative part of that construction for many children (Feeney & Moravcik, 2005). Cutter-Mackenzie, Payne, Reid, and Burke (2010) state, “children’s literature variously represents, mediates, and informs experiences and understandings of diverse environments and places as well as the people and ‘presences’ (that may be, are no longer, or never are) found therein” (p. 253). Similarly, Feeney and Moravcik (2005) explain that children’s literature can create models for positive problem solving and support the development of values such as cooperation and interdependence. Picturebooks are a logical tool for developing meaningful science understandings for elementary students (Mantzicopoulos & Patrick, 2010). By its very nature, the genre is didactic and can offer teachings concerning science ethics, morals, values, and beliefs and consequently they may be accustomed to looking for lessons within picturebooks.

Picturebooks have the potential to present information in a way that can relate facts to the child’s world and way of thinking (Wells & Zeece, 2007). They create a background and context for academic learning on a cognitive level (Carr et al., 2001). This context is crucial to engaging students in science content. Barclay et al. (2012) explain, “Children’s literature is a valuable science tool [because] it generates interest and motivation, provides context, invites communication, and connects science with the rest of the child’s world” (p. 149). In describing the use of children’s literature to teach
math, Ward (2005) explains that integrating literature into the curriculum depicts mathematics in the real world and makes it come alive, thus conveying real meaning to students. These ideas can be applied to integrating science and literature as well as math because science is also a discipline that uses a discrete set of vocabulary and skills to understand and explain the physical world.

The power of context and enjoyment for motivating students to learn cannot be understated. Helterbran & Strahler (2013) state; “Students become more actively engaged in the learning process if they are intrinsically motivated by assignments or expectations that ignite curiosity, interest, or enjoyment. If students see purpose or applicability in their work, they are far more likely to engage in and complete assignments” (p. 312). Reisberg (2008) similarly argues that happiness promotes connection and engagement. Modern picture books are ideal for promoting enjoyment while presenting information. Comber, Cremin, & Hall (2013) explain that before the 18th century, children’s literature was designed specifically for instructional purposes and generally implied rote memorization. Because today’s children’s literature is often developed for the commercial market, authors and illustrators strive to create appealing work that provides enjoyment for readers (Carr et al., 2001). In elementary grades, the use of picture books, something associated with fun, can make science disciplines seem more interesting and exciting than when they are presented in traditional classroom formats. In discussing the merits of incorporating literature into mathematics instruction Price and Lennon (2009) assert that, “Students who struggle with concepts can benefit from an approach that often is less intimidating and more entertaining” (p. 4). The element of enjoyment in picturebooks can potentially shift student attitudes towards
learning. In supporting the concept of a place-based pedagogy of pleasure, Reisberg (2008) argues that pleasurable learning can deepen accessibility to difficult subjects because engagement and connection are integral parts of happiness. Atkinson, Matousevich, & Huber (2009) argue that “students frequently find trade books to be more interesting and easier to read than textbooks” (p. 485). This is important because gains in knowledge are often associated with interest and appreciation for a subject (Matzicopoulous & Patrick, 2011). However, most schools don’t focus on centering learning on student interests. A United Kingdom government report from 2004 found that schools rarely built upon student reading interests (Comber et al., 2013). As a result, there is often a decline in reading interest when students transition into secondary education. They begin to view reading as work that is strictly monitored and regulated by a system (Comber et al., 2013, p. 247). By capitalizing on student interests in the primary grades, a foundation of interest may be built for subsequent science and literacy instruction.
Building Literacy

Visual Literacy. In today’s society we are constantly bombarded by images. Understanding visual information is becoming increasingly important with the rise of screen-based cultures and their multimodal forms of interaction and exchange (Bishop & Hickman, 1992; Cutter-Mackenzie et al., 2010; Williams, 2007). The New Literacy studies movement is based on an understanding that literacy can take many different forms and may vary across social and cultural settings (Williams, 2007). This new movement advocates expanding literacy from a narrow view that includes reading and writing to include other modes of communication and understanding including visual representations. In an effort to expand his students’ conceptions of literacy, Williams (2007) integrated visual literacy into a primary grade classroom. He encouraged his students to ‘read’ a painting just as they would read a text. His work found that at first his students struggled to create meaning from images as easily as from text. However, the students were able to expand their idea of reading and create meaning from the paintings, which prompted colorful discussions and increased interest in visuals in other domains of life.

Visual literacy is similar to text literacy in that it requires comparable cognitive demands such as integration of information and inferential skills. Williams (2007) defines visual literacy as “the personal construction of meaning from any type of visual image” (p.637). Although this is central to daily life, there is little didactic emphasis on it in the classroom. Williams (2007) states, “Considering the shift toward more visual texts, it is unfortunate that the classroom literacy curriculum, as well as standardized testing, remains overly concerned with the printed text” (p. 636). Building visual literacy in the classroom is important because there are positive cognitive and social outcomes from
interpreting visual data but students must understand the system underlying visual communication. Nodelman (1981) explains, “Just as our understanding of language depends on our knowledge of the grammar that gives it shape, our understanding of pictures depends on our knowledge of the conventions by which they operate” (p. 57). These conventions have been described as “visual grammar” (Nodelman, 1981).

Many aspects of visual grammar are inherently understood and utilized by skilled illustrators to deepen the complexity of their images. Studies have shown that children develop the ability to use elements of visual grammar and to expect pictures to have personal and social meaning with very little help or instruction (Styles & Arzipe 2001; Wolfenbarger & Sipe, 2007). The role of teachers therefore should be to strengthen visual literacy and to demonstrate that text and images are both valuable means of conveying and extracting information.

Molly Bang explains the significance of shape and light in her book ‘Picture This: How Pictures Work’ (2000). She points out how certain components of an image such as position, contrast, or relative size can evoke affective responses. For example, white backgrounds imply safety, while black backgrounds create unease because humans see well in the daytime but cannot see in the dark. Pointed or jagged shapes evoke fear while curved or rounded shapes make viewers feel more secure and comfortable. These types of image elements evoke varied levels of cognitive, affective, and cultural understandings that can result in a more holistic understanding where readers can absorb multiple meanings simultaneously (Walsh, 2003). The affective potential of images and the ability to capture temporal sequences support the common saying “a picture is worth a thousand words”.
Educating students about different forms of literacy and communication helps them understand that knowledge can be represented in multiple ways. Understanding and interpreting multiple modes of information presentation is an important skill to develop for a variety of disciplines but especially for science. An examination of professional science texts shows that they operate in a multimodal manner where scientists combine, interconnect, and integrate text with a variety of visual representations such as diagrams, photos, graphs, maps, drawings and others (Smolkin & Donovan, 2005). Visual representations are effective at describing complex relationships, and can enhance comprehension of “multi-layered, intricate, and integrated connections” (Manifold, 2000, p.30). Visuals are commonly employed by scientists to convey complex relationships or concepts. Although visuals used for science communication are often abstract, teaching students to view illustrations as a source of important information can encourage habits that may persist into adulthood when illustrations turn to models and figures. In addition, the practice of examining a visual to construct meaning builds valuable observation skills, which is an important scientific practice (Pringle & Lamme, 2005). It is therefore important for teachers to emphasize the value of visuals to students as a source of information.

Text literacy. In addition to strengthening students’ abilities to interpret images, picturebooks also help to develop reading skills. The Common Core standards emphasize the importance of building reading skills for both literary and informational texts in elementary grades so that students are prepared for secondary schooling (National Governors Association Center, 2010). With continuing shifts in national education reforms and standards requiring increased testing, it is difficult for teachers to provide
students enough time in each discipline to build a sufficient base of knowledge for cumulative education (Romance & Vitale, 2012). The time allocated to science instruction in elementary classrooms is estimated to be less than 10% of instructional time (Mantzicopoulos et al., 2009). As a result, students often go into middle school lacking an understanding of science. A lack of prior knowledge is one of the primary culprits behind poor performance for secondary students and hit students of low socio-economic status especially hard. Romance and Vitale (2012) state:

When considered from a broader perspective, the evidence suggests that the United States is neither providing the general population with the levels of literacy in science necessary to support learning complex science concepts nor the level of reading comprehension proficiency necessary for being successful in the workplace and acting as informed citizens. (p. 507)

Such a problem is rooted in the lack of instructional time in elementary grades and its solution will require a reevaluation of traditional curricular structure. There is increasing support for the idea of interdisciplinary integration of science and reading (Mayer, 1995; Romance & Vitale, 2012). Research shows that science instruction which involves conceptually related reading and writing can enhance science learning while also boosting reading comprehension and proficiency (Romance & Vitale, 2012). In addition, studies have shown that the integration of science and literacy not only results in higher performance scores but also boosts enthusiasm for science (Broemmel & Rearden, 2006). By using time efficiently for integrated science education in K-5, students will be better prepared for secondary science and concurrently improve reading
comprehension in grades 3-8 (Romance & Vitale, 2012). One way to approach this type of interdisciplinary integration is to use children’s literature for science instruction.

There is increasing recognition that picture books can have an important role for developing language, reading and writing skills (Bishop & Hickman, 1992). In a study of how children use visual and verbal texts to construct meaning, Feathers and Arya (2012) found that children often use illustrations to help with difficulties processing text. In early education, picture books can be helpful for developing reading comprehension by providing hints for unfamiliar words or concepts. However, picture books are also valuable for older students. The ability of pictures to create layers of meaning when combined with text can result in more complex strategies of interpretation and understanding (Comber et al., 2013). As a literal narrative progresses, illustrations can be critically viewed for a deeper understanding of the topic (Manifold, 2000).

Integrating science and reading is also important because language is such a central element of science disciplines. Yore (2004) states:

Language is both a means of doing science and of constructing scientific claims and an end in that it is used to communicate inquiries, procedures, and science understandings so that other people can assess the validity of the knowledge claims, make critical decisions about the claims, and take informed actions on related problems. (p.72)

Communication is critical because of the social nature of science (Rutherford & Ahlgren, 1990). Using picture books can develop reading and writing skills, deepen science content knowledge, and develop a “language of science” (Pappas, 2006). Mantzicopoulos and Patrick (2011) explain, “During reading, children learn the functions
and structure of the language of science as they ask questions, describe their observations and experiences, explain, justify, and summarize” (p. 271). These language skills not only increase student comfort in discussing their understandings of science concepts but also provide a foundation for the study of other subjects (Michaels et al., 2008; Price & Lennon, 2009).

In addition, reading science books develops content-specific terminology, which provides a base for future science learning (Kurtz & Bartholomew, 2012). When students have the appropriate vocabulary to discuss scientific content, they are more comfortable discussing their understandings (Price & Lennon, 2009). This is important for communicating information, which is one of the emphasized skills in the eight NGSS science and engineering practices (NGSS, 2013).

**Scientific Practices**

Children tend to be naturally curious and full of questions about the world around them. If the essence of empirical science is validation by observation, then children are born scientific investigators (Barclay et al., 2012; Rutherford & Ahlgren, 1990). Illustrated children’s literature can capitalize on this innate quality by encouraging observation, asking questions, predicting next events and other practices that are at the root of empiric scientific investigation. Mantzicopoulos and Patrick (2011) explain, “during reading, children connect their prior knowledge with information from the book’s pictures and written text, use strategic processes to identify key concepts, synthesize and summarize information, make inferences, and anticipate what comes next in the story” (p. 269). Although the field of science involves many types of methods in addition to empiricism, it is important to develop empirical skills as a foundation for future science
learning. When examined closely, there are many parallels between reading comprehension and science practices. The ability to continually re-evaluate knowledge in relation to new information and to alter ideas accordingly is a key scientific practice and central to critical reading (Michaels, et al., 2008).

Teton Science Schools use the science circle (Figure 1) to capture the iterative nature of scientific investigation. Although this model is overly simplistic and does not accurately represent science in reality, it is a useful starting point for introducing young students to inquiry and is an example of appropriate inaccuracy. Similarly, a hermeneutic analysis of text “starts with the whole, proceeds to look at the details, goes back to the whole with a better understanding, and so on in an eternal circle” (Nikolajeva & Scott, 2006, p. 2). The verbal information creates expectations for the visual, which further informs the verbal and so on. Each form of communication creates new experiences, which build on one another to expand understanding. The hermeneutic process explains how children read picturebooks as well. Nikolajeva and Scott (2006) state, “The reader turns from verbal to visual and back again, in an ever expanding concatenation of understanding. Each new rereading of either words or pictures creates better prerequisites for an adequate interpretation of the whole” (p. 2). When children read picturebooks over and over again they are likely delving more deeply into the meaning and reevaluating their understanding of the details (Nikolajeva & Scott, 2006). Because text is the dominant form of communication in our society, many adults
have lost the ability to read picture books this way and may view illustrations as decorative accompaniments as opposed to sources of insight. The hermeneutic approach to reading parallels the iterative scientific process. It is important to encourage students to hold onto this skill and read critically by engaging in visual communication in order to develop understanding of science practices. If iterative analysis becomes ingrained in the way students learn, they may be more likely to think critically and scientifically.

Monhardt and Monhardt (2006) sum up the importance of instilling these skills in young learners:

> Certainly not all children will become practicing scientists someday, but it is hoped that the scientific attitudes that are beneficial for all individuals, children can acquire through engaging with process skills which will help them to become problem solvers, able to apply these skills in real-world contexts. (p. 68)

Building these practices is important for continued science education and developing positive science attitudes (Wells & Zeece, 2007).

Children’s literature is especially effective for developing science practices because it can provide a situated perspective which results in cognitive functions such as reasoning, remembering, and thinking critically (Carr et al., 2001; Monhardt & Monhardt, 2006; Sackes et al., 2009). In addition, children’s literature can provide a real-world setting for science concepts. An important aspect of science practices is developing authentic questions generated from student experience and relating concepts to the real world (Edwards, 1997; NGSS, 2013). Well-selected children’s literature can provide the starting point for students to see how science relates to their everyday life. Stories that
depict other children doing scientific investigations can also combat the idea that a scientist is someone in an ivory tower, distanced from the everyday experiences of children (Ford, 2006). Students will come to realize that the basic principles of what scientists do in the real world is similar to what students do in effective science classrooms (Michaels et al., 2008). In addition, books that show science being conducted allow children to visualize how scientific knowledge is produced. The understanding that science is not composed of discrete facts but is instead based on a hypothetical-deductive method is an important piece of the nature of science. The National Research Council (2012) states:

Any education that focuses predominantly on the detailed products of scientific labor- the facts of science- without developing an understanding of how those facts were established or that ignores the main important applications of science in the world misrepresents science and marginalizes the importance of engineering. (pp. 42-43)

Through picturebooks, science practices can be illustrated and applied, which can boost interest in the sciences at a crucial developmental stage. Stimulating interest in science is especially important for creating positive attitudes about physical sciences. The current educational system has created an environment where older students are accustomed to providing memorized answers in science classes rather than original questions or ideas (Edwards, 1997). This formulaic approach to learning does not accurately represent the realities of science nor does it develop science practices. As Kurtz and Bartholomew (2012) state, “the ability to infer, reason, recall, and retell may not be the natural ‘offspring’ of the rote, fact-based approach to learning” (p.185).
However, if picturebooks are used as a medium for awakening innate curiosity and creativity, children may naturally engage in beginning science practices (Sackes et al., 2009). Many picturebooks depict scientists such as Carl Sagan, Rachel Carson, or James Audubon as science role models. The heroic nature of these depictions are useful for captivating elementary science interest but it is important that the books also convey the importance of determination and diligence. If students see that goals can be reached through imagination, perseverance and hard work it will set them up for success as they pursue science or any other discipline.

Picturebooks can also promote imagination and creativity. These are important aspects of science that are often absent from traditional curriculum (Sackes et al., 2009; Welchman-Tischler, 1992). One of the goals of the NGSS standards is to make students understand that “the work of scientists and engineers is a creative endeavor- one that has deeply affected the world they live in” (NRC, 2012, p. 43). In a world where traditional curriculum materials are generally too structured for genuine inquiry, illustrated children’s literature might be able to provide the necessary freedom and room for creativity to develop science process skills (Edwards, 1997).

Critical Thinking Skills

The ability to think critically is an essential competency for life in the 21st century (Kettler, 2014). National education standards have increased the focus on developing these skills in the classroom as studies have shown that critical thinking is broadly transferable to a variety of disciplines and an important part of being an active citizen. A study by Ketter (2014) found that differences in critical thinking skill development are
present by the spring semester of fourth grade. Therefore there should be a strong focus on developing these skills in elementary grades. Ketter also found that there is a relationship between cognitive ability and critical thinking skills. The data indicated that 36% of the variance in critical thinking skills is related to cognitive ability. While this information may discourage some teachers from feeling that critical thinking can be successfully taught, there is potential to develop students’ cognitive ability. According to Boston (2003), knowledge and intelligence itself is based on the ability to take new information and fit it to a schema or learned technique of organizing and interpreting information. Intelligence can thus be distilled to having a well-organized brain, capable of matching new information to prior experience quickly in order to solve problems (Romance & Vitale, 2012). Robert Schank studies narratology, which is a study of how narrative structure affects our perception of the world around us. Schank argues that stories are an important means of organizing knowledge.

A story is useful because it comes with many indices. These indices may be locations, attitudes, quandaries, decisions, conclusions, or whatever. The more indices we have for a story that is being told, the more places it can reside in memory. Consequently we are more likely to remember a story and relate it to experiences already in memory. In other words, the more indices, the greater the number of comparisons with prior experiences and hence the greater the learning. (Schank, 1995. p. 11)

Narrative not only allows for more efficient integration of new information in the brain but it also makes that information more accessible in our memory (Schank, 1995). Thus current learning theory and cognitive science lead us back to our ancestors.
Storytelling, used by humans to communicate ideas for thousands of years, is an excellent way to facilitate learning and memory. The use of storybooks is therefore an obvious means of developing cognitive ability and learning for early elementary grades. These cognitive abilities in turn build important critical thinking skills.

Illustrated children’s literature is also useful for developing critical thinking skills because it can provide students with opportunities for meta-cognitive reflection on their own beliefs and perspectives. Williams (2007) states:

Reading is not neutral but in fact highly individual, filtered through a personal, social, and cultural context. We should strive to give children more exposure to visual images, especially in a way that allows them to freely develop their critical thinking as well as their own meanings uniquely rooted in their personal experience. (p. 641)

Reading children’s literature in the elementary grades is important because it can afford openings for dialogue with and against the dominant social culture at a point when children are beginning to form their own worldviews. “The heartbeat of critical thinking is the longing to know- to understand how life works. Children are organically predisposed to be critical thinkers” (hooks, 2010, p. 7). If these predispositions can be intentionally cultivated, students may be less likely to conform and submit to authority. When students look at the who, what, when, where, and how of things, they will inevitably face incompatible as well as compelling views of the world (Cutter-Mackenzie et al., 2010). It is important for children to actively construct their own worldviews. Children’s books are one way to provide students with a variety of interpretations and perspectives with which to challenge and develop their worldviews. hooks (2010) argues
that critical thinking “places us in opposition to any system of education or culture that would have us be passive recipients of ways of knowing” (p. 185). This active style of evaluating information is important for being an involved, democratic citizen and also for practicing science.

At the heart of science is the idea of iteration. Science is the practice of continuing to question, evaluate, and make logical connections even when alternative explanations may exist. In order for scientists to be successful it is important to constantly challenge what is “known”. It is important for scientists to overcome native egocentrism and sociocentrism in order to avoid bias and view problems from multiple perspectives. Teaching students to think critically is one way to instill these values (Helterbran & Strahler, 2013). Teachers can use picture books to introduce different perspectives, concepts, or cultures, which can be a starting point for discussion. At the elementary stage, “critical thinking skills must be scaffolded, with educators assisting children in learning how to think critically” (Helterbran & Strahler, 2013). Students must be taught that their ideas have value when supported with evidence, and that these ideas are worthy of discussion, even when they contradict the ideas of peers or authors. Creating a positive learning environment focused on discussing elements of a story and reflecting on characters, settings, and implicit messages can show students that their ideas can be valuable, and that they should continue to practice questioning things in their surrounding environment.

The Challenges of Using Picture Books to Teach Science

One of the primary difficulties of using picture books to teach science content is the potential for engendering misconceptions (Hug, 2010). Most children’s books are
marketed towards the public with the intent of winning awards and selling as many copies as possible. Because not all picture books are developed specifically for the educational market, they are not held to content standards like textbooks (Ford, 2006). Fictional picture books that include elements of fantasy can be especially challenging when there are science concepts sprinkled throughout (Mantzicopoulos & Patrick, 2011). It can be difficult for students to recognize which parts are accurate and which parts are not. It has been questioned whether the presentation of science concepts in a fictional context actually confuses children and interferes with science learning (Mayer, 1995). In addition, the complexity of science requires that explanations be simplified well into college, let alone elementary school. Although simplifications can arguably present science content inaccurately, it is often necessary for developmentally appropriate instruction. For 3rd through 5th grade, teachers may decide to select books that are appropriately inaccurate. Selection resources are especially helpful for finding the balance between appropriately inaccurate content and misconception-forming inaccuracies. Selection resources are discussed in the next section of this literature review.

Anthropomorphism of animals is another commonly used literary device in both fiction and nonfiction picture books that can create misconceptions and stereotypes about the animal kingdom (Marriott, 2002). Hug (2010) suggests that misunderstandings stemming from anthropomorphism can contribute to detrimental environmental behaviors. Children’s literature can shape children’s conceptualizations of nature and their understanding of the human-environment relationship (Hug, 2010). However, there are also benefits associated with anthropomorphism, such as creating a sense of empathy
for animals. In general, when anthropomorphism is employed in books, teachers should carefully examine how misunderstandings could evolve and discuss it with students.

Illustrations also play a big role in potential misinformation. When depictions are embellished or modified for aesthetics they can often lead to misunderstandings. Many studies have found that the moon is often misrepresented in illustrations and that it leads to a lack of accurate understanding for both children and adults (Trundle & Troland, 2005). Encouraging students to make observations of the illustrations compared with observations from scientific photographs or other data can be a good way to introduce students to critical thinking and the practice of observation.

Misconceptions can also form around children’s understanding of the nature of science (Ford, 2006). When scientists are depicted in stereotypical ways or concepts are presented as facts, misunderstandings are subtly reinforced. Even when authors try to convey degrees of uncertainty, it is often difficult to convey to young learners that facts are often based on theories that can be revised and built upon (Ford, 2006). Therefore it can be difficult to convey the complexities of science disciplines with picture books alone (Ford, 2006). Picturebooks must be a part of a larger conversation about what it means to be a scientist.

Since picturebooks combine two levels of communication, the verbal and visual, there is ample opportunity for readers to have individual experiences when reading the same book. Authors and illustrators often employ a contradictory pull of words and pictures which leaves room for readers to fill in the gaps with their personal knowledge (Nikolajeva & Scott, 2006; Nodelman, 1981). This is both a limitation of and an opportunity for the use of picturebooks in science classrooms. Teachers must be aware
that students may experience books differently and encourage questions and discussions to create a positive learning environment where a culture of investigation and inquiry exists.

The consensus in the literature for dealing with these challenges is to select books carefully, and to invite critical thinking and inquiry from students. Pringle and Lamme (2005) state that a good book for science learning must “allow the readers to make observations and raise questions toward understanding their world” (p. 4). Similarly Sackes and Trundle (2009) suggest that teachers should lead students in a discussion where they are encouraged to ask questions and think about the content presented in books. Another tactic for minimizing misconceptions is to pair fiction books with non-fiction books and ask students to identify discrepancies between the two (Sackes & Trundle, 2009). Teachers can also encourage students to use multiple sources to determine accuracy for themselves. Here accuracy would mean the claim or depiction that is supported by multiple sources of evidence. When misconceptions are quickly addressed, students may avoid integrating misinterpretations into their schema of understanding (Chi et al., 2012). However, once misconceptions are lodged in memory, it can be very difficult to change them and these misunderstandings can persist into adulthood (Ozgur, 2013). Therefore misconceptions must be identified and discussed, so that students can build knowledge and think critically about what they are reading.

Selecting Appropriate Books for Science Classrooms

One of the challenges in using children’s books for teaching science is selecting appropriate books. Many teachers agree that there is a place for picture books in classrooms but opinions on the exact role of the books is more varied (Comber et al.,
Many teachers also feel that their science knowledge is not sufficient to determine whether the content represented in books is accurate or appropriately inaccurate (Hug, 2010). However with the rise in popularity of informational books due to common core literacy standards, there are many resources to help teachers select science picturebooks. Checklists, selection criteria, rubrics, evaluation scales, and bibliographies are widely available (Atkinson et al., 2009; Carr et al., 2001; Donovan & Smolkin, 2002; Mayer, 1995; Price & Lennon, 2009). The rubric created by Atkinson, Matusevich & Huber is an especially helpful resource for teachers or parents evaluating fiction and nonfiction children’s books for science education (Appendix C).

Donovan and Smolkin (2002) argue that there are three major categories that are important in the selection of books for science (Figure 2). Genre refers to the type of text (narrative, non-narrative etc.) and the text structure. Structure is important because the type of text and awareness of text-structure can play a major role in shaping student learning and facilitating comprehension (Mantzicopoulos & Patrick, 2010). Content is important to consider in the selection of picturebooks for science because misrepresentations and simplification are common in picturebooks intended for young readers. There is a common misconception that children are simple minded, incapable of being presented with accurate science content (Mantzicopoulos & Patrick, 2010; Nodelman, 1981). As a result there is a plethora of books about science themes that are not science books. Paying close attention to content is key to selecting appropriate science texts. The presence of visual features is another important factor in selecting suitable books. In well-crafted picturebooks the author, illustrator, and designer should work together so that all components of the book combine to present the information
(Wolfenbarger & Sipe, 2007). Figure 2 presents a succinct overview of these elements in order to guide the selection of books.

<table>
<thead>
<tr>
<th>An overview of the elements to consider when selecting books for science</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Genre</strong></td>
</tr>
<tr>
<td>Four typical genres found in schools</td>
</tr>
<tr>
<td>- Story, nonnarrative information, narrative information, dual purpose</td>
</tr>
<tr>
<td><strong>Features that determine genre</strong></td>
</tr>
<tr>
<td>1. Linguistic features—how meaning is related within and across sentences, including vocabulary and syntax</td>
</tr>
<tr>
<td>2. Global elements—the overall structuring of “chunks” of the text, such as setting, initiating event, and so forth</td>
</tr>
<tr>
<td>3. Global structure—relationships among ideas as represented visually by a tree, or skeletal, diagram</td>
</tr>
<tr>
<td><strong>Content</strong></td>
</tr>
<tr>
<td>1. Accuracy—the degree to which information is precise, straightforward, and reliable or wrong, misleading, and unreliable</td>
</tr>
<tr>
<td>2. Complexity—includes the following:</td>
</tr>
<tr>
<td>- depth and breadth (the complexity of topic coverage—how much, in how much detail)</td>
</tr>
<tr>
<td>- informational ideas (the number of ideas in text relevant to the topic)</td>
</tr>
<tr>
<td>- lexical density (measure of content’s compactness: clauses divided by ideas)</td>
</tr>
<tr>
<td>- reading level (the difficulty of the text; readability)</td>
</tr>
<tr>
<td><strong>Visual features</strong></td>
</tr>
<tr>
<td>- Illustrations/photographs—attributes of the pictures created or photographed to accompany the text; particular attention must be given to captions and their purpose</td>
</tr>
<tr>
<td>- Diagrams—charts, tables, graphs, and other structures used to plot information</td>
</tr>
<tr>
<td>- Text—features of the actual print, in terms of placement, size, amount per page, and fonts</td>
</tr>
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**Figure 2**: An overview of the elements to consider when selecting books for science (Donovan & Smolkin, 2002, p. 503).

There are also many other resources for selecting science books. Teacher’s Choices, (IRA and CBC), Outstanding Science Trade Books for Students K-12, (NSTA), Notable Children’s Book List (ALA), Robert F. Silbert Informational Book Award, Orbis Pictus Award for Outstanding Nonfiction, and the Washington Post Annual Children’s Book Guild Non-fiction award are excellent examples of accessible selection resources (Brommel & Rearden, 2006; Atkinson et al., 2009).
Fiction

Although there is some debate about whether or not there is a place for fiction in science classrooms, there are many proponents who argue that fiction can enrich science concept instruction (Mayer, 1995). Narrative is a fundamental part of the human experience, which allows people to “make sense of individual and collective experience and construct knowledge through storytelling” (Comber et al., 2013, p. 245). Storytelling spans time and culture as a means of learning about the world and passing on knowledge by identifying with characters, remembering plot lines, and retelling stories to others. Because narrative is so elemental in knowledge construction, it is logical to use it in a classroom (Sackes et al., 2009). Mantzicopoulos & Patrick (2010) state, “the popularity of fictional text is anchored in the view that children are predisposed to learning from stories because the story form is a fundamental tool for the construction and organization of meaning” (p. 415). Although there are increasing examples of narrative nonfiction, character and plot development are an integral part of fiction picture books. As a reader comes to know a character, the story becomes personalized which creates a meaningful context for remembering the content presented in the story (Carr et al., 2001). Picture books also provide more opportunity for visual learners than most textbooks (Carr et al., 2001; Pringle & Lamme, 2005). However, because fiction is written with the intent of entertainment, it is important to select books carefully to ensure that accurate content is being presented that won’t create misconceptions. Mayer (1995) states “the emphasis on using children’s literature to teach science concepts should be placed on choosing fiction presented without bias, with fine, realistic illustration, and most important of all, with the accurate presentation of science concepts” (p. 43). In addition to selection, facilitation is
also a crucial component of successful picturebook use in the science classroom. Chapter Three presents books that exhibit these qualities and gives suggestions for activities that can help facilitate science learning.

**Nonfiction**

Our society surrounds us with expository text. Atkinson et al. (2009) estimate that 86% of adult reading deals with information. Whether it is manuals, maps, signs, or guides, the average person must be able to interpret expository text. Not only is it an important component of success in everyday life but also in school. Fictional texts are widely used in elementary school and there are concerns that the focus on fictional texts may limit children’s ability to comprehend informational texts later in their education (Mantzicopoulos et al., 2009). There is also concern that an overemphasis on fiction could negatively affect children’s long-term attitudes and interests in learning (Mantzicopoulos & Patrick, 2010). It has been shown in multiple studies that children not only are capable of reading and understanding informational texts but that they enjoy, and sometimes prefer, it (Lamme & Fu, 2001; Mantzicopoulos & Patrick 2010; Mantzicopoulos et al., 2009; Palmer & Stewart, 2005). It is important for students to be introduced to nonfiction reading in primary education so that students can learn the format and structure and the similarities and differences between reading fiction and nonfiction (Palmer & Stewart, 2005). Palmer and Stewart (2005) suggest that teacher read-alouds are effective ways of familiarizing children with nonfiction. They argue that it is important for students to understand that nonfiction is different from fiction in that it doesn’t have to be read cover to cover. Readers can search for specific facts or answers to questions. There are also benefits to using nonfiction trade books over textbooks. It is
argued that textbooks do not provide the same opportunities for teaching critical thinking (Lamme & Fu, 2001). The abstract, technical vocabulary can present content as superficial, fragmented, and can leave little room for interpretation or perspective (Atkinson et al., 2009). In addition, readability of textbooks is often beyond the intended grade level and the content becomes outdated as theories and understandings evolve (Atkinson et al. 2009; Donovan & Smolkin, 2002). Conversely, informational trade books are specifically designed to appeal to children and focus on specific science concepts, which is useful for instructional purposes. In addition, with thousands of books being published every year, trade book content is often more up to date than textbooks and production quality is higher (Ford, 2006).

Utilizing informational books in elementary grades is also beneficial for integrating science and literacy. By using nonfiction texts in the classroom, teachers can teach content while also developing student comprehension and critical reading and thinking skills. Palmer and Stewart (2005) state, “nonfiction can help readers engage in critical thinking and research needed to build meaningful knowledge and understanding in content area subjects” (p. 427). Simultaneously children are familiarized with informational formats such as diagrams, footnotes, captions, and labels. These elements of expository text are important to understand in order to process more complex science materials. Pappas (2006) suggests that informational picturebooks can develop scientific linguistic registers, “the language of inquiry, observation, and logically arrived at hypotheses for observed phenomena” (Wolfenbarger & Sipe, 2007, p. 276). Therefore children’s nonfiction literature is a holistic means of developing skills that will be valuable for students as they continue their education.
Hybrids

There are increasing examples of narrative nonfiction which contain elements of both fiction and nonfiction picture books. These types of books often have colorful and engaging illustrations more typical of fiction books than the photography-dominated nonfiction genre. Hybrid books can also employ “two parallel message lines” (Pappas, 2006). The upper message line is similar to narrative format. The lower message line presents information typical of the language of nonfiction books. Some authors use narrative text accompanied by informational captions or diagrams. *Tornadoes!* by Gail Gibbons (2010) and *Volcano Rising* by Elizabeth Rusch and Susan Swan (2013) are examples of informational books that exhibit these hybrid qualities. The illustrations in these books are bright, engaging, artistic, and accurate. Both authors employ two types of text: one more similar to a fictional narrative structure, and one more characteristic of nonfiction informational captions. Hybrid books are useful for teaching science because they will appeal to a broader audience of children than either fiction or non-fiction alone and are less likely to contain inaccuracies, which can lead to misconceptions. The majority of the books examined in this Plan B project fall into the hybrid category.

Postmodern Picturebooks

Postmodern picturebooks provide interesting opportunities for readers to construct their own interpretation of truth and think critically. Wolfenbarger and Sipe (2007) define postmodern picture books as those that “include nonlinearity, self-referential text, a sarcastic or self-mocking tone, and an anti-authoritarian stance” (p. 275). The nonlinear structure works against the traditional linear storytelling pattern and often includes multiple stories occurring simultaneously. Sidebars, borders, or illustrations that conflict
with text are ways authors and illustrators create multiple narratives and ideas (Wolfenbarger & Sipe, 2007). Figure 3 shows an example and explains the postmodern elements of Anthony Browne’s *Zoo* (1994). The illustration and text portray different realities and begs the reader to answer the question: who are the real animals? Postmodern picturebooks are useful for promoting students to think critically about how they interpret information and that text should be questioned. However, despite the classroom potential for these books, it is difficult to find postmodern picturebooks with science content. By nature, postmodern picturebooks are complex and depict multiple realities and therefore it may be difficult to incorporate science content at a 3rd to 5th grade level. However I believe it is possible to do so and that there is great potential for the trade book industry to include postmodern science picturebooks to encourage critical science thinking.
Anthony Browne’s *Zoo* (1994) uses the illustrations to tell an anti-authoritarian narrative that is counter to the text. Humans are cleverly depicted with animal features and are often shown behind bars or glass, which gives the viewer the perspective of a zoo animal. Ultimately the reader absorbs a message that is completely independent from the text narrative.

**Figure 3: Example of Postmodernism**

**How to Use Children’s Literature in the Classroom**

“Ultimately a good science picture book not only satisfies a reader’s curiosity but also leads to more questions being asked and answers pursued” (Pringle & Lamme, 2005, p. 4). Presenting science content is an important piece of using picturebooks in the classroom but the real potential comes with providing a context for scientific practices. Through skilled questioning teachers can initiate discussions and develop students’ science process skills (Barclay et al., 2012). Discussions encourage students to come up with their own questions, hear different perspectives, and think critically about the information and presentation of a picturebook. This can be an excellent starting point for
students to come up with researchable questions. Palmer and Stewart (2005) present three models for using nonfiction in the classroom. Model 1 consists of teacher-directed instruction where teachers model how to extract information from a text in order to answer a question. The use of study guides or worksheets can be particularly useful at this stage and are appropriate for primary grade classrooms (Palmer & Stewart, 2005). Model 2 is a scaffolded student investigation where students pair up to make a poster or report based on study guide questions using the researching skills they developed in Model 1. The third model builds on the previous two models by encouraging independent student investigation. Self-selected research projects allow students to become “miniexperts” and share their learning with the class through presentations. Because a project of this sort will likely require more in-depth information than what can be found in a single picturebook, this type of assignment will familiarize students with extracting information from multiple sources and synthesizing information. Research projects of this type can support nonfiction literacy, critical thinking, create a starting point for science practices, and develop research skills that are useful for secondary education.

Books that depict other children doing science can empower students to come up with their own research ideas. Books with environmental themes might encourage students to critically examine and investigate their surroundings and human-environment interactions. Picturebooks can also provide just enough information to pique curiosity and initiate the desire to research a topic further. Transferring information gained from a depiction of science to the actual doing of science can awaken curiosity, capture interest, and motivate students’ continued study of science disciplines (NRC, 2012).
Picturebooks can also be the starting point for other activities such as writing, drawing, speaking, debating, or acting. These types of activities not only reinforce understanding of the content but also develop communication skills that are valuable to all disciplines but especially science (Mantzicopoulos & Patrick, 2010). Rutherford and Ahlgren (1990) state, “because of the social nature of science, the dissemination of scientific information is crucial to its progress” (p. 6). Communication is an extremely important aspect of science that receives proportionately little attention in science classrooms. Focusing on ways for students to communicate scientific understandings in different formats is a valuable skill for success in the sciences.

Presenting scientific findings is another important form of science communication. It is beneficial to provide opportunities for students to publicly showcase their work within the community. Providing students with an authentic audience with whom to share what they’ve learned can be a powerful motivation for students (Palmer & Stewart, 2005). Krechevsky, Mardell, and Romans (2014) state, “Nurturing children’s relationships with their communities has numerous benefits for both the children (who engage in meaningful learning) and the adults (who come to see the world in new ways)” (p. 17). Documenting children’s learning processes and products can challenge adult assumptions of children’s abilities, bring alternative images of learning to the public, and give children a voice in order to empower them to value their own ideas and knowledge (Krechevsky et al. 2014). Focusing on topics in the community can also reinforce the importance and relevancy of science to everyday life.

Many of these activities are useful for science and literacy integration programs. Question answering, summarizing, and post writing activities are positively associated
with reading comprehension and also with retaining content information (Palmer & Stewart, 2005). Yore (2004, pp. 88-89) suggests the following strategies for integrating science and literacy:

- Assessing the importance, validity and certainty of textual claims
- Generating questions about the topic to set the purpose for reading
- Detecting main ideas and summarizing them
- Inferring meaning
- Skimming, elaborating, and sequencing
- Using text structure to anticipate and comprehend ideas
- Improving conceptual networks (concept mapping) and memory
- Monitoring comprehension
- Self-regulating to address comprehension failures

These strategies can help teachers to break the boundaries between science and literacy learning and encourage students to see the connections between different disciplines. In addition, reading fiction and nonfiction books on a subject and asking students to compare and contrast the two can encourage students to think critically about what they read, build literacy, and develop content knowledge. Mantzicopoulos and Patrick (2011) state, “teachers should consider pairing fictional with expository texts during instruction. This would offer unique opportunities for engaging children with both genres as they discuss the content and compare and contrast the content and features of each” (p. 272). Similarly Comber et al. (2013) argues “teachers should use multiple texts on linked themes, juxtaposing the texts [and] allow the children to respond to the texts in meaningful ways so that transformation of knowledge becomes a possibility” (p. 250). These comparative activities strengthen critical thinking skills while also developing literacy and science content understanding.
Literature Review Conclusion

Although the emphasis on developing science skills in elementary school has been increasing, there is still a trend in underestimating the cognitive ability of young children (Mantzicopoulos et al., 2009). It is extremely important to develop accurate understandings of the nature of science by combining content with practice. Emphasizing science education and encouraging critical thinking in late elementary grades can boost interest and establish a foundation for secondary science learning. By strengthening elementary science education children may develop science attitudes that inform life-long behavior, and ultimately increase science literacy in the United States.

Quality fiction and nonfiction picturebooks are readily available for classrooms. Economic competition for awards and honors incentivizes authors to continue to refine content and presentation in order to create popular, well-selling products. Picturebooks can provide relevance and context, which can motivate young students to pursue science interests. The dual communication methods employed by picturebooks develop visual and text communication skills, which is increasingly important in this digital era. There is also opportunity to develop critical thinking skills, science practices, and enthusiasm for continued motivation to learn. Thus an accessible yet often overlooked tool like picturebooks can have far reaching influences beyond its use in early elementary grades.

While there is agreement among teachers and scholars that there is a place for picturebooks in teaching science, in order for picturebooks to be an effective teaching tool there must be careful selection and implementation. The rest of this project is devoted to providing examples of appropriate or appropriately inaccurate picturebooks for science instruction and specific examples of how they can be used in 3rd through 5th
grade classrooms in order to create a resource for teachers and parents wishing to incorporate picturebooks into their teaching practice.
Chapter 3

Product Description

This chapter is intended to provide examples of appropriate children’s books and to exemplify how they can be incorporated into curriculum. Although there is consensus within the literature that picturebooks can be effective science teaching tools, not all picturebooks will create positive learning outcomes. It is important for teachers to carefully select works that are appropriate for science teaching that will not engender misconceptions about content and the nature of science or reinforce stereotypes. Wells and Zeece (2007) argue that it is crucial that literature selections do not, “give a false sense of the real world” if environmental learning and science content acquisition is intended (p. 287). Donovan and Smolkin (2002), Pringle and Lamme (2005), and Atkinson and colleagues (2009) assert that careful selection of science trade books can be guided with the following questions:

- Is science content explicitly presented?
- Is the author qualified to write about the topic(s)?
- What background knowledge does the author assume of the reader?
- Are content specific vocabulary words appropriately included within the text?
- Is the work interesting and engaging, up to date, and developmentally appropriate for the intended audience?
- Is the nature of science accurately presented with real-life examples?
- Do illustrations and/or text use different perspectives and depict animals in their natural habitats?
- Do illustrations complement the text and convey additional information?
- Are illustrations accurate with relational sizes and proportionality?
- Are stereotypes avoided in the depiction of “scientists” and are women and minorities positively represented?

Using these questions, the rubric developed by Atkinson, Matusevich and Huber (Appendix C), and other selection criteria described in the literature, I created my own set of guiding criteria to select books:
科学技术内容准确或适当不准确
- 适当科学术语使用
- 概念适宜发展
- 插图有助于而非重复信息
- 插图视觉吸引人且艺术上成功传达信息
- 当出现时，科学实践被描绘为可获得和有用工具
- 当出现时，科学家角色不局限于较老的白人男性。少数族裔、女性和儿童被显示实践科学
- 该书是吸引人和愉快阅读
- 事实可辨认而非虚构
- 科学和技术在3-5年级适宜

我使用这些标准来选择10本书来审查，以便提供第二章（图4）中讨论概念的示例。使用模板（图5），书籍在类型、内容、视觉特征、课堂使用和适用的标准方面进行了分析。来自《下一代科学标准（NGSS）》和《共同核心信息性阅读标准》。虽然有大量优秀的生命科学图画书可选，但我尝试挑选在其他科学领域中符合我标准的书籍。虽然我发现了优秀的物理科学、地球和空间科学、工程、技术和应用科学书籍，但这些领域中绝对需要更多符合上述标准的书籍。许多现有的信息性书籍是图书馆和书店中对学生研究一个主题更深入的资源，但它们对于实现本文献综述中描述的目标并不那么有用。

这10本书被分为以学科为基础的章节。‘科学学科’指的是与书籍相关的具体科学领域。这四个类别包括生命科学、物理科学、地球和空间科学、工程、技术和应用科学。
<table>
<thead>
<tr>
<th>Life Science</th>
</tr>
</thead>
</table>
| *Feathers: Not Just For Flying*  
By Melissa Stewart, Illustrated by Sarah S. Brannen  
Charlesbridge, 2014 |
| *The Salamander Room*  
By Anne Mazer, Illustrated by Steve Johnson  
Knopf, 1991 |
| *The Drop in My Drink: The Story of Water on Our Planet*  
By Meredith Hooper, Illustrated by Chris Coady  
Viking, 1998 |
| *How To Clean a Hippopotamus*  
By Steve Jenkins and Robin Page  
Houghton Mifflin, 2010 |

<table>
<thead>
<tr>
<th>Earth Science</th>
</tr>
</thead>
</table>
| *Star Stuff: Carl Sagan and the Mysteries of the Cosmos*  
By Stephanie Roth Sisson  
Roaring Brook Press, 2014 |
| *Volcano Rising*  
By Elizabeth Rusch, Illustrated by Susan Swan  
Charlesbridge, 2013 |
| *Nobody Particular: One Woman’s Fight to Save the Bays*  
By Molly Bang  
Henry Holt and Company, 2000 |
| *Everybody Needs a Rock*  
By Byrd Baylor, Illustrated by Peter Parnall  
Charles Scribner’s Sons, 1974 |

<table>
<thead>
<tr>
<th>Physical Science</th>
</tr>
</thead>
</table>
| *My Light*  
By Molly Bang  
Blue Sky Press, 2004 |

<table>
<thead>
<tr>
<th>Engineering, Technology, and Applied Science</th>
</tr>
</thead>
</table>
| *The Boy Who Harnessed the Wind*  
William Kamkwamba and Bryan Mealer, Illustrated by Elizabeth Zunon  
Dial, 2012 |

**Figure 4:** A Summary of Selected Picturebooks

The disproportionate number of examples in various categories is somewhat characteristic of the availability of appropriate books for that discipline. Studies have shown that physical science, earth science, and engineering and technology concepts are underrepresented while life science concepts are overrepresented in children’s literature (Sackes et al. 2009). My experience selecting books was similar. Although I found a disproportionate amount of life science content, I also found several excellent earth
science books and included four of them as examples. However, in reality earth science concepts do not make up 40% of the market as the ratio of my examples would suggest. In cases where books related to more than one discipline, they were placed in the category that is more dominantly represented by the book.

The template (Figure 5) was created to organize information and enable quick references for specific information. It is divided into five subjects: Book Information, Content, Visual Elements, Standards, and Classroom Uses. Grade level is presented in the book information segment and is based on the applicable NGSS Disciplinary Core Ideas, Science and Engineering Practices, Crosscutting Concepts, and Common Core Informational Literacy Standards. In addition the Lexile Measure for each book is listed to give an indication of the reading level. Many of these books would likely be enjoyed and found informative by a wide range of ages. However, in the context of teacher use, the given grade level and Lexile Measure estimates ages where the book can be most productive for classroom science instruction. This segment also contains a section for genre. Genre is classified as fiction or nonfiction. In cases where a book is a hybrid of fiction and nonfiction, the genre will be further described as having a narrative format, or dual text (both narrative and informational text on each page).

The content segment includes science disciplines, topics, a summary, and additional resources. ‘Topics’ describe the content subjects that are within the book. These sections are intended to provide easy reference by teachers looking for a book that connects to a subject they are going to cover in class. The ‘resources’ section describes additional resources contained within the book. Examples of these types of resources include bibliographies, glossaries, or appendices. Beneath the template, related books
may be listed. These are books that relate to science disciplines or topics and can be referenced in the Bibliography of Children’s Literature for Science Content Teachers (Appendix B).

Because visual literacy was an important component of this literature review, there is an entire segment devoted to explaining the visual elements of the book. The ‘aesthetic description’ section is intended to explain the noteworthy visual characteristics that contributed to the selection of the book. ‘Informational elements’ refers to the types of visual information commonly found in informational texts such as diagrams, sidebars, labels, or captions. This type of visual information is important for developing student familiarity with using informational texts and is also a contributing factor to the selection of appropriate books.

‘Standards’ are intended to help teachers choose books that relate to their curricular goals. NGSS, and Common Core are important standards used by teachers in Wyoming and across the country and are included for easy reference. Applicable standards were selected based on the proposed classroom uses and do not capture all of the potential connections to standards.

The ‘classroom uses’ section is intended to stimulate ideas about the range of ways these books can be used in the classroom. This last segment presents activity ideas related to applicable standards but it could be a useful starting point for developing lesson plans or project ideas for science classrooms.
Summary

The template created for this project is a tool that can help teachers evaluate elements of a picturebook in order to determine if the book is beneficial for science education. The template, combined with the criteria listed in Chapter Three, the rubric developed by Atkinson, Matusevich, and Huber (Appendix C) and additional sources listed in the references, can help guide teachers in the selection of books that have the
kind of qualities that promote critical thinking and science learning. The templates in Appendix A also provide a resource for teachers that can be easily shared and referenced.

The books described in Appendix A are examples of exemplary picturebooks. Although there is a plethora of picturebooks available, the search for books that met the criteria described in this project was not easy. There is a plentiful supply of books with science content but there are fewer examples of books that actively encourage critical thinking and science practices. Although appropriate science content and presentation are extremely important, the manner in which a book is facilitated can also be powerful. Using picturebooks as a teaching tool can provide creative opportunities for both teachers and students. The intent of this research is to encourage elementary science teachers to think differently about how science is presented and how it can be taught via picturebooks.

In the course of my research I learned that science education has come a long way in the last 15 years. However, I think my personal experiences as a student are still shared by many youth across the country. An understanding of science is important for living in today’s world where “science, engineering, and technology permeate nearly every facet of modern life” (NRC, 2012, p. 1). It is especially important that science be presented appropriately to students at an age when they are building foundations for their future schooling. By depicting science as something that is accessible and relevant to different types of thinkers, they may be drawn to science careers through this creative approach. Diversity of thinking styles and perspectives are critical to developing solutions for the challenging problems facing society today. Using picturebooks in the elementary grades
can develop the kind of scientific critical thinking skills that are necessary for becoming a contributing member of society now and in the future.
References


## Appendix A

### Selected Children’s Books

**LIFE SCIENCE**

<table>
<thead>
<tr>
<th>#1</th>
<th>Title</th>
<th><em>Feathers: Not Just for Flying</em></th>
</tr>
</thead>
</table>
|    | Author | By Melissa Stewart  
Illustrated by Sarah S. Brannen |
|    | Grade Level(s) | 3-4 |
|    | Lexile Measure | 910L |
|    | Publishing Information | Charlesbridge, 2014 |
|    | Awards/Honors | International Reading Association, Teacher’s Choice  
2015 ALA Notable Children’s Book  
Junior Library Guild Selection |
|    | Genre | Nonfiction |
|    | Science Discipline | Life Science |
|    | Topic(s) | Birds, Adaptations, Evolution, Structure to Support Survival |
|    | Summary | Feathers are compared to tangible everyday objects. This is an effective method of highlighting how varied and specialized feathers are. The author and illustrator successfully convey the versatility of feathers and the structural differences that determine their use.  

The largest text on the page delivers a narrative-like flow to the book. Beneath the upper text is information in a caption format that elaborates on the narrative text in relation to the specific species depicted on the opposite page. Full-page illustrations accompany the information with the name of the bird species and the location where the illustration takes place. The multiple modes of information presentation are an excellent way to introduce students to informational texts. |
<table>
<thead>
<tr>
<th>Resources</th>
<th>The last page explains ‘kinds of feathers’ and highlights the fact that understanding is continuing to evolve and not all scientists agree about classification systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informational Elements</td>
<td>Captions, labels, figures</td>
</tr>
<tr>
<td>Aesthetic Description</td>
<td>The illustrations are accurate and aesthetically pleasing and the use of shadows create a 3-D realism that draws the reader in. Illustrations imitate qualities of a field notebook. The font is similar to handwriting script and shadows, pins, scotch tape, staples, and other objects suggest that someone collected information and stored it in the book. The full-page illustrations include species and habitat information. These elements combine to create an appealing representation of a journal or field notebook.</td>
</tr>
</tbody>
</table>
| NGSS Disciplinary Core Ideas | 4LS1-1  
4LS4-2 |
| NGSS Science and Engineering Practices | Practice 6  
Practice 8 |
| NGSS Crosscutting Concepts | 1. Patterns  
6. Structure and Function |
| Common Core | CCSS.ELA-LITERACY.RI.3.5 |
| Classroom Uses | -Research and present on one of the birds exhibited in the book  
-Design a bird based on research information  
-Discuss misconceptions: How are feathers different from the objects they are compared to? |

RELATED BOOKS: *The Beetle Book*, Steve Jenkins; *Eye to Eye*, Steve Jenkins
<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th><em>The Salamander Room</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author</strong></td>
<td>By Annie Mazer</td>
</tr>
<tr>
<td></td>
<td>Illustrated by Steve Johnson</td>
</tr>
<tr>
<td><strong>Grade Level(s)</strong></td>
<td>3-4</td>
</tr>
<tr>
<td><strong>Lexile Measure</strong></td>
<td>660L</td>
</tr>
<tr>
<td><strong>Publishing Information</strong></td>
<td>Alfred A. Knopf, 1991</td>
</tr>
<tr>
<td><strong>Awards/Honors</strong></td>
<td>Reading Rainbow Feature Books, 1991</td>
</tr>
<tr>
<td><strong>Genre</strong></td>
<td>Fiction</td>
</tr>
<tr>
<td><strong>Science Discipline</strong></td>
<td>Life Science, Environmental Science</td>
</tr>
<tr>
<td><strong>Topic(s)</strong></td>
<td>Human-Environment Interactions, Habitats</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>This book provides a starting point for discussions about different habitats. The text and illustrations work independently and together within the narrative to show the differences between Brain’s habitat and that of the Salamander. Imagination takes over as Brian designs the perfect room for the Salamander. The product of Brian’s wildest imagination however becomes a natural area similar to where he originally found the salamander. This book communicates the wonder of natural places and can encourage readers to explore the outdoors. The story provides a context for discussing different environments and the similarities and differences between human and animal habitats. This book can encourage students to empathize with animals and value the complexities of natural habitats.</td>
</tr>
<tr>
<td><strong>Resources</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Informational Elements**

**Aesthetic Description**
The illustrations are colorful and engaging. The first page has clear distinction between the text and the illustration. The borders of the illustration are crisp and defined. However, as the story progresses and Brian responds to his mother’s questions, the illustrations and text become more
connected. By the end, the text and the illustrations have no separation. As the boundaries of the illustrations are broken down so are the boundaries of reality. The perspective of the illustrations continually shifts so the viewer sees the room through the eyes of different creatures.

| NGSS Disciplinary Core Ideas | 3-LS4-3  
<table>
<thead>
<tr>
<th></th>
<th>3-LS4-4</th>
</tr>
</thead>
</table>
| NGSS Science and Engineering Practices | Practice 6  
|                              | Practice 8  |
| NGSS Crosscutting Concepts  | 4. Systems and System Models |
| Common Core                 | CCSS.ELA-LITERACY.RL.3.7 |
| Classroom Uses             | -Discussion: How are the salamander’s needs different from Brian’s?: Protecting habitats, environmental restoration and rehabilitation.  
|                            | - Research an animal and make/present a design plan for how to convert the classroom into the ideal habitat |

RELATED BOOKS: *Just a Dream*, Chris Van Allsburg; *The Wump World*, Bill Peet
<table>
<thead>
<tr>
<th>Title</th>
<th><em>The Drop In My Drink: The Story of Water on Our Planet</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>By Meredith Hooper</td>
</tr>
<tr>
<td></td>
<td>Illustrated by Chris Coady</td>
</tr>
<tr>
<td>Grade Level(s)</td>
<td>3-5</td>
</tr>
<tr>
<td>Lexile Measure</td>
<td>740L</td>
</tr>
<tr>
<td>Publishing Information</td>
<td>Viking, 1998</td>
</tr>
<tr>
<td>Awards/Honors</td>
<td></td>
</tr>
<tr>
<td>Genre</td>
<td>Nonfiction: narrative format</td>
</tr>
<tr>
<td>Science Discipline</td>
<td>Life Science, Earth Science, Physical Science</td>
</tr>
<tr>
<td>Topic(s)</td>
<td>Water Cycle, States of Matter, History of the Earth, Surface Processes, Human-Environment Interactions</td>
</tr>
<tr>
<td>Summary</td>
<td>This book travels through time to explain the journey of water since the very beginning of Earth’s existence. The role of water is explained in its different states and in the different parts of the water cycle. In addition, the book explains the crucial role water has played since the beginning of life on earth. The book successfully communicates that water is a precious resource that is necessary for all life and something that cannot be taken for granted. The end of the book emphasizes that humans have the potential to destroy water resources and that it is important to protect this precious life-giving resource in order to ensure the future of life on earth.</td>
</tr>
<tr>
<td>Resources</td>
<td>‘The Water Cycle’ and ‘Amazing Water Facts’</td>
</tr>
<tr>
<td>Informational Elements</td>
<td></td>
</tr>
</tbody>
</table>
| Aesthetic Description | Vibrant colors and an artistic style transport the viewer to environments through time to successfully communicate the incredible journey water has had on Earth. Prehistoric organisms, dinosaurs, caves, deep-sea creatures and more exotic images are contrasted with a relatable image of a child taking a drink of water. This contrast brings the significance of water home and emphasizes that the importance of water is often taken for granted. The final illustration depicts a
child standing in the water with a net which encourages readers to get out and personally explore this amazing resource. Although the illustrations do not necessarily provide additional information, they effectively create an emotional understanding of the importance of water.

| NGSS Disciplinary Core Ideas | 5-PS1-3  
| 5-LS2-1  
| 4-ESS2-1  
| 5-ESS2-1  
| 5-ESS2-2 |

| NGSS Science and Engineering Practices | Practice 3  
| Practice 4  
| Practice 5 |

| NGSS Crosscutting Concepts | 3. Scale, Proportion, and Quantity  
| 7. Stability and Change |

| Common Core | CCSS.ELA-LITERACY.RI.5.2  
| CCSS.ELA-LITERACY.RI.4.3  
| CCSS.ELA-LITERACY.RI.3.2 |

| Classroom Uses | -Provides a context for water quality investigation in local water sources (Stream Team)  
| -Create a graph or diagram to describe the distribution of water on Earth |

RELATED BOOKS: *A Drop Around the World*, McKinney/Maydak
<table>
<thead>
<tr>
<th>Title</th>
<th>How to Clean A Hippopotamus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Steve Jenkins and Robin Page</td>
</tr>
<tr>
<td>Grade Level(s)</td>
<td>3-5</td>
</tr>
<tr>
<td>Lexile Measure</td>
<td>950L</td>
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<tr>
<td>Publishing Information</td>
<td>Houghton Mifflin Harcourt, 2010</td>
</tr>
<tr>
<td>Genre</td>
<td>Nonfiction</td>
</tr>
<tr>
<td>Science Discipline</td>
<td>Life Science</td>
</tr>
<tr>
<td>Topic(s)</td>
<td>Symbiosis, Habitats</td>
</tr>
<tr>
<td>Summary</td>
<td>The unique format of this book communicates symbiosis in an accessible, engaging way. A comic book-style design combines with beautiful multimedia illustrations to draw the reader in and hold their interest. The comic strip format combines elements of informational text (captions, insets etc.) but also creates a fun, approachable context for learning ecological information. The nature of the formatting also allows readers to reference text as opposed to reading through the pages sequentially. The breadth of the relationships described is incredible and informative for both children and adults. The book ends by describing the human-dog symbiotic relationship which makes the concept of mutualistic symbiosis personally relevant.</td>
</tr>
<tr>
<td>Resources</td>
<td>The last few pages of the book describe the concept of symbiosis in more depth and reference the uncertainty of scientists in understanding and classifying all behaviors. In addition, the size, habitat, and diet of all the animals presented in the book are listed here. There is also a list of selected works for learning more about symbiosis.</td>
</tr>
<tr>
<td>Informational Elements</td>
<td>Captions, insets, non-linear format</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Aesthetic Description</td>
<td>The aesthetic imagery does not compromise the accuracy of the illustrations. Textured paper cutouts give depth to the images while also conveying information about the texture and color of the animals. The size, habitat, and diet descriptions of the animals at the end of the book also complement the images to maximize the accuracy of the animal depictions.</td>
</tr>
</tbody>
</table>
| NGSS Disciplinary Core Ideas | 3-LS4-2  
3-LS2-1 |
| NGSS Science and Engineering Practices | Practice 8 |
| NGSS Crosscutting Concepts | 4. Systems and System Models  
6. Structure and Function |
| **Common Core** | CCSS.ELA-LITERACY.RI.3(4).1  
CCSS.ELA-LITERACY.RI.3.5  
CCSS.ELA-LITERACY.RI.3.7  
CCSS.ELA-LITERACY.RI.5.3 |
| Classroom Uses | Discussion: How would animals be affected if their symbiotic partners were removed from an environment? Can humans have symbiotic relationships with one another?  
-Symbiosis charades in pairs  
-Student pairs research a symbiotic relationship and create a poster to display in the school |

**RELATED BOOKS:** *Eye to Eye*, Steve Jenkins; *The Beetle Book*; Steve Jenkins; *Hide-and-seek Science*, Emma Stevenson
**Title** | *Star Stuff*
---|---
**Author** | Stephanie Roth Sisson
**Grade Level(s)** | 3-5
**Lexile Measure** | Unknown
**Publishing Information** | Roaring Book Press, 2014
**Awards/Honors** | 2015 Orbis Pictus Honor Book  
| 2015 ALA Notable Children’s Book
**Genre** | Nonfiction: Narrative format
**Science Discipline** | Earth/Space Science
**Topic(s)** | Science Practices, Solar System, Outer Space

**Summary**
This biographical picturebook follows the life of Carl Sagan. Although this book reads like a story, there is lots of accurate science information contained within the pages. It is written in a narrative format with earth science information included in the illustrations. This book is a good example of a work that breaks down stereotypes about the nature of science and who scientists are. By showing Carl as a young, curious boy, the author indicates that following your curiosities and interests can lead to big science discoveries.

**Resources**
The end of the book contains an Author’s Note, Notes, Bibliography and Sources, and Source Notes. These resources provide additional science information and can serve as a starting point for further research on the topics presented.

**Informational Elements** | Labels

**Aesthetic Description**
The illustrations not only include labels, speech bubbles, and science information, but also portray a sense of scale that is difficult to do with text alone. The first two pages illustrate the vastness of the galaxy in relation to our cities and neighborhoods. The illustrations also include...
Centerfolds that allow for active interaction with the text and peak curiosity about what Carl is discovering as he researches Space. The soft, colorful style of the illustrations also contributes to the feeling of approachability of earth science and science practices in general.

| NGSS Disciplinary Core Ideas | 5-ESS1-1  
| 5-ESS1-2 |
|---|---|
| NGSS Science and Engineering Practices | Practice 2  
| Practice 3  
| Practice 4 |
| NGSS Crosscutting Concepts | 3. Scale, Proportion, and Quantity  
| 4. Systems and System Models |
| Common Core | CCSS.ELA-LITERACY.RI.5(4,3).9  
| CCSS.ELA-LITERACY.RI.3.7 |
| Classroom Uses | -Build a solar system model  
- Hypothesize/record observations about shadows on the playground and length of day  
- Compare and Contrast Carl’s science practices with the characters in one of the related books below |

**RELATED BOOKS:** *The Boy Who Drew Birds*, Davies/Sweet; *Rachel Carson and Her Book That Changed the World*, Lawlor/Beingessner; *Me...Jane*, Patrick McDonnell
<table>
<thead>
<tr>
<th>Title</th>
<th><strong>Volcano Rising</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>By Elizabeth Rusch Illustrated by Susan Swan</td>
</tr>
<tr>
<td>Grade Level(s)</td>
<td>3-5</td>
</tr>
<tr>
<td>Lexile Measure</td>
<td>1090L</td>
</tr>
<tr>
<td>Publishing Information</td>
<td>Charlesbridge, 2013</td>
</tr>
<tr>
<td>Genre</td>
<td>Nonfiction: Dual text</td>
</tr>
<tr>
<td>Science Discipline</td>
<td>Earth Science, Geology</td>
</tr>
<tr>
<td>Topic(s)</td>
<td>Volcanoes, Human-Environment Interactions</td>
</tr>
<tr>
<td>Summary</td>
<td>This picturebook uses engaging illustrations and dual text to draw readers in to the science of volcanoes. The dual text combines a narrative flow (upper text) with factual information (lower text). The combination makes the book useful for scaffolding information for different abilities and familiarizes readers with components of informational text. The lower text includes facts and numerical figures about specific volcanic events. The book takes the reader around the world to different volcanic events and shows how humans interact with these geologic events. The scope of the different events dispels the common misconception addressed on the first page. The book goes on to emphasize the power of volcanic forces and how prevalent yet diverse they are all over the earth.</td>
</tr>
<tr>
<td>Resources</td>
<td>A list of the vocabulary words along with their definitions is presented at the end of the book with a Selected Bibliography.</td>
</tr>
<tr>
<td>Informational Elements</td>
<td>Labels</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Aesthetic Description</td>
<td>The active, colorful, mixed media artwork successfully illustrates the energy of different types of volcanoes and contains labels that define different volcanic vocabulary words.</td>
</tr>
</tbody>
</table>
| NGSS Disciplinary Core Ideas| 4-ESS3-2  
5-ESS3-1  
3-ESS3-1                                                                 |
| NGSS Science and Engineering Practices | Practice 6                                                                 |
| NGSS Crosscutting Concepts  | 3. Scale, Proportion and Quantity  
7. Stability and Change |
| Common Core                 | CCSS.ELA-LITERACY.RI.3(4).3  
CCSS.ELA-LITERACY.RI.3.5  
CCSS.ELA-LITERACY.RI.5.7 |
| Classroom Uses              | -Research a historical or active volcano using vocabulary and resources presented in the book  
- Explain methods used by humans and then design a solution for a chosen researched volcanic event |

**RELATED BOOKS:** *Tornadoes!* Gail Gibbons
<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>Nobody Particular: One Woman’s Fight to Save the Bays</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author</strong></td>
<td>Molly Bang</td>
</tr>
<tr>
<td><strong>Grade Level(s)</strong></td>
<td>5+</td>
</tr>
<tr>
<td><strong>Lexile Measure</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Publishing Information</strong></td>
<td>Henry Holt and Company, 2000</td>
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<td><strong>Awards/Honors</strong></td>
<td>Booklist’s 1000 Best Young Adult Books Since 2000</td>
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<td><strong>Genre</strong></td>
<td>Nonfiction: Dual narrative</td>
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<td><strong>Science Discipline(s)</strong></td>
<td>Physical Science, Earth Science</td>
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<tr>
<td><strong>Topic(s)</strong></td>
<td>Environmental Quality, Human-Environment Interactions, Critical Thinking</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>This book uses a comic book format to explain the story of Diane Wilson- a shrimp fisherwoman in Louisiana who took on factories to fight for environmental regulation of pollution. Diane voices her lack of confidence in her own ability to make change but her success shows that anyone with enough determination can make an impact in their community. Two narratives simultaneously tell stories. Black and White comic strip style text tells the story of Diane Wilson’s crusade while the colored background tells the ecological story of the bay. There is a lot of information included in the book and it may take multiple readings to fully absorb everything. The comic text is dense but the graphic novel style may draw young readers in.</td>
</tr>
<tr>
<td><strong>Resources</strong></td>
<td>Update on the story p. 46</td>
</tr>
<tr>
<td><strong>Informational Elements</strong></td>
<td>The colored background includes labeled illustrations of the geology, ecology, and culture of the bay.</td>
</tr>
<tr>
<td><strong>Aesthetic Description</strong></td>
<td>Colorful illustrations border the centrally placed black and white comic book illustrations. Visually the black and white sections might pose a challenge because the text is small and dense and the eye is drawn outwards to the colored sections. However, the black and white contrasts</td>
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with the color to tell stories on different timescales. This visual strategy effectively presents dual narratives.

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<td>Common Core</td>
<td><strong>CCSS.ELA-LITERACY.RI.5.3</strong></td>
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<tr>
<td><strong>Classroom Uses</strong></td>
<td>-As a class, identify a local community issue and design a strategy to create positive change</td>
</tr>
<tr>
<td><strong>Title</strong></td>
<td><em>Everybody Needs a Rock</em></td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td><strong>Author</strong></td>
<td>Baylor/Parnall</td>
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<td><strong>Grade Level(s)</strong></td>
<td>3-4</td>
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<td><strong>Lexile Measure</strong></td>
<td>430L</td>
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<td><strong>Publishing Information</strong></td>
<td>Charles Scribner’s Sons, 1974</td>
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<td><strong>Genre</strong></td>
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<td><strong>Science Discipline(s)</strong></td>
<td>Earth Science</td>
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<tr>
<td><strong>Topic(s)</strong></td>
<td>Science practices, Observation Skills, Geology</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>This book introduces science process skills and emphasizes that these processes are not formulaic or rigid. The narrator describes 10 guidelines for selecting a rock that encourages observation with different senses. The lack of scientific terminology makes the book less useful for introductory geology lessons but ideal for promoting natural exploration and observation of surroundings, and developing an appreciation for nature.</td>
</tr>
</tbody>
</table>

**Resources**

**Informational Elements**

**Aesthetic Description**

The minimalist illustrations artistically complement the tone of the narrator. Perspectives are given from various viewpoints and the somewhat abstract quality of the images leaves room for the reader’s imagination.

**NGSS**

4-ESS2-2

**NGSS Science and Engineering Practices**

Practice 8

**NGSS Crosscutting Concepts**

2. Cause and Effect

**Common Core**

CCSS.ELA-LITERACY.RL.3.4
CCSS.ELA-LITERACY.RL.3.7
| Classroom Uses | - Develop your own 10 rules  
|                | - Select a rock using the book’s 10 rules. Then write a story about the life of the rock based in geologic research |

**Related Books:** *A Rock is Lively*, Aston/Long
#9

<table>
<thead>
<tr>
<th>Title</th>
<th>My Light</th>
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<tbody>
<tr>
<td>Author</td>
<td>Molly Bang</td>
</tr>
<tr>
<td>Grade Level(s)</td>
<td>3-5</td>
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<td>Lexile Measure</td>
<td>690L</td>
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<tr>
<td>Publishing Information</td>
<td>The Blue Sky Press, 2004</td>
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<td>2005 ALA Notable Children’s Book</td>
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<td>Science Discipline(s)</td>
<td>Physical Science and Life Science</td>
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<td>Topic(s)</td>
<td>Energy, Renewable Energy, Electricity, Photosynthesis, Human-Environment Interactions</td>
</tr>
<tr>
<td>Summary</td>
<td>My Light, told from the perspective of the Sun, explains how energy is derived from sunlight. The book presents accurate (though simplified) explanations of how energy is transformed in nature and by humans. Connections are made between the industrial and the natural world, explaining different methods of creating and storing energy.</td>
</tr>
<tr>
<td>Resources</td>
<td>‘About This Book’ contains more in depth explanations</td>
</tr>
<tr>
<td>Informational Elements</td>
<td>Technical diagrams</td>
</tr>
<tr>
<td>Aesthetic Description</td>
<td>The illustrations work both independently and collaboratively with the text to create meaning. The informational complexity is balanced by colorful and engaging drawings, which may make the topic more approachable for novices. Bang uses illustrations to emphasize the connections between the natural and industrial world. The book begins by showing the visual similarities between the stars in the sky and the city lights to begin her point that they both come from the same source of energy. She uses small yellow dots to depict energy in its different forms as it</td>
</tr>
</tbody>
</table>
travels in clouds, rivers, coal beds, wind, and transmission lines. She strategically uses the color yellow to represent energy, which is a useful method of visually communicating how energy travels through our world and how it is all connected.

Wind and solar power are portrayed most favorably, with benign colors and imagery that contrast with the ominous storm clouds, and harsh colors used in the depiction of hydroelectric and coal powered electricity.

| NGSS Disciplinary Core Ideas | 5-PS3-1  
4-PS3-4  
4-PS3-2  
5-LS1-1 |
|-------------------------------|----------|
| NGSS Science and Engineering Practices | Practice 1  
Practice 2  
Practice 3  
Practice 4  
Practice 5 |
| NGSS Crosscutting Concepts | 4. Systems and System Models  
5. Energy and Matter |
| Common Core | CCSS.ELA-LITERACY.RI.3.7  
CCSS.ELA-LITERACY.RI.4.7  
CCSS.ELA-LITERACY.RI.5.2 |
| Classroom Uses | -Discussion: Think critically about the differences between renewable and nonrenewable energy sources  
-Think critically about how everyday things like light bulbs are connected to more abstract concepts like million year old plants or stars in outer space.  
-Carry out an investigation: Grow plants and provide varying levels of sunlight  
-Design a device that converts energy from one form to another  
-Create a flow chart of how the sun’s energy moves into our bodies |
#10

**Title**  
The Boy Who Harnessed The Wind

**Author**  
By William Kamkwamba & Bryan Mealer  
Illustrated by Elizabeth Zunon

**Grade Level(s)**  
3-5

**Lexile Measure**  
910L

**Publishing Information**  
Dial Books for Young Readers, 2012

**Awards/Honors**  
International Reading Association, Teacher’s Choice

**Genre**  
Fiction: biography

**Science Discipline**  
Engineering & Technology, Earth Science, Physical Science

**Topic(s)**  
Renewable Energy, Electricity, Engineering and Technology

**Summary**  
This book follows the true story of William Kamkwamba who built a windmill in his village in Malawi. Faced with famine and drought, William used his local library to research and design a windmill to power electricity and irrigation. Using materials he collected from the junkyard, William used ingenuity and determination to positively impact his community. Because William co-authored the book, the depiction of the story and the Malawi culture is likely devoid of inappropriate stereotypes.

This book reinforces the idea that engineering and technology can solve relevant problems and that accomplishments like this are achievable for children and minorities.

**Resources**  
Epilogue

**Informational Elements**

**Aesthetic Description**  
The multimedia artwork is colorful, engaging, and combines reality, imagination, realism, and abstraction in an aesthetically pleasing way. Paper cutouts and paint combine to create beautiful images on every page which
illustrate the vibrant Malawi culture.

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<td>6. Structure and Function</td>
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<tr>
<td></td>
<td>CCSS.ELA-LITERACY.RL.3.7</td>
</tr>
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</table>

| Classroom Uses | -Define a problem and design an object, tool, process etc. with criteria for success and analysis of materials, time, and cost to solve the problem |
Appendix B

Bibliography of Children’s Literature for Science Content Teachers

The following list of books exhibit some or all of the qualities described in this project. This is not an exhaustive list and is only intended to provide examples so that teachers may successfully select their own books based on these titles and the selection criteria described in Chapter 3.

- See template

- See Template

- See Template

- An impressively illustrated but anthropomorphized fictional account of a young bat learning to use echolocation. Useful for critical comparing and contrasting with informational books.

- A postmodern fiction book about a family who visits the zoo for the day to look at animals. However, the real spectacle seems to be the humans.

- A description of the life of John Audubon and the science practices that led to his life’s work with birds.

- An engaging and well illustrated informational text about tornadoes

• See Template

• This book explains how different animals’ eyes have adapted for their own special uses

• A book that explains the incredible diversity of beetles and the adaptations that have developed within the insect order.

• See Template

• See Template

• A biography of Rachel Carson and the events and questions that led to her work as a pioneering environmentalist.

• See Template

• A story about Jane Goodall’s childhood and the curiosities and interests that led to her career as pioneering scientist

• A book that describes the water cycle and the movement of water around the world in its different forms.

• This fictional book gives a perspective on environmental degradation from the perspective of the imaginary Wumps.

• See Template

- A beautifully illustrated book that familiarizes readers with animals found in different types of habitats and the camouflage strategies those animals employ to survive.

- See Template

- A life science book that describes the important ecological role a tree plays even after it has died.

- A fictional story with an environmental message that follows a boy in his dreams of a future world that shows the results of mistreating the environment.
## Appendix C

Atkinson et al., 2009 Rubric

### Figure 1

**Science Trade Book Evaluation Rubric**

<table>
<thead>
<tr>
<th>Book title:</th>
<th>Author:</th>
<th>ISBN:</th>
<th>Copyright date:</th>
<th>Out of print: Yes/No (If out of print, carefully attend to whether science content is current.)</th>
</tr>
</thead>
</table>

Science content of book: (Check all that apply.)

- Details professional scientists engaged in inquiry
- Facts/Concepts
- Presents science through an engaging/enjoyable story
- Details “how to” experiments

Before reviewing the book, answer these three questions:
1. Does the book have substantial science content (scientists at work and/or scientific information)?
2. Is the science content (text, scale, vocabulary, and graphics) accurate?
3. Is the science content current?

If the answer to any of the above three questions is “no,” do not continue the evaluation.

<table>
<thead>
<tr>
<th>Science criteria</th>
<th>Yes</th>
<th>Somewhat</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the book’s science content presented “as an everyday endeavor” so that students can connect it with some of their own experiences or so that they can participate as “scientists in the making” (i.e., pose “I wonder” questions or explore further)?</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
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Is the book’s science content personalized by putting a human face on science practice (presenting scientific inquiry/discovery “in action” through engaging narratives, showing specific inquiry skills in action by “expert scientists”)?

<table>
<thead>
<tr>
<th>Science criteria</th>
<th>Yes</th>
<th>Somewhat</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the book’s science content intellectually and developmentally appropriate for its audience?</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
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Literacy Criteria—framed to fit fiction/nonfiction genres

Complete either A or B.

**A. Fiction:** Does the plot exhibit good development, imagination, and continuity? Are the characters (if any) well-developed?

<table>
<thead>
<tr>
<th>Science criteria</th>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the book’s content include adequate information presented in a clearly organized and appropriate text structure?</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Does the book contain a vivid and interesting writing style that actively involves the reader?

<table>
<thead>
<tr>
<th>Science criteria</th>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
</table>

(continued)
### Science Trade Book Evaluation Rubric

| Are the book's illustrations and graphics text-relevant, appealing, and representative of a child's perspective? | 5 4 3 2 1 |
| Comments: | Excellent | Poor |

| Are the book's readability and interest level developmentally appropriate for its intended audience? | 5 4 3 2 1 |
| Comments: | Excellent | Poor |

| Do the book's content information, style, graphics/illustrations, and story/text structure complement one another? | 5 4 3 2 1 |
| Comments: | Excellent | Poor |

For nonfiction only: Do access features (table of contents, index, heading, sidebars, glossary, author's notes, bibliographies, epilogues, captions, etc.), offer additional information that explains, extends, or verifies information in the book? | 5 4 3 2 1 |
| Comments: | Excellent | Poor |

For each of the criteria below, rate the book from a child's perspective and from a literacy perspective.

**Final reviewer evaluation:**
1. Average the scores for this review related to Science Criteria; repeat for Literacy Criteria.
2. Select values below based upon the average of scores from the Science Criteria and followed by the Literacy Criteria. Round each score to a tenth of a point.

| Rating of this book from a science perspective: | 5 4 3 2 1 |
| Superb | Recommended | Use With Caution | Marginal | Unacceptable |

| Rating of this book from a literacy perspective: | 5 4 3 2 1 |
| Superb | Recommended | Use With Caution | Marginal | Unacceptable |

**Directions for considering scores for this book across all reviewers:**
1. Average final value science scores for all reviewers (preferably three, at least one with science expertise).
2. Average final value literacy scores for all reviewers.
3. Final average science / Final average literacy

To be considered for classroom use, a book should receive final average scores in the 4-5 range for science and in the 4-5 range for literacy.

---

Note: Rubric by Terry Atkinson, Lisa Huber, and Melissa Manevich; adapted with permission from Hunsider, P.D. (2004). Mathematics trade books: Establishing their value and assessing their quality. The Reading Teacher, 57(7), 618-629.
Appendix D
Defense PowerPoint Presentation

USING CHILDREN’S PICTUREBOOKS TO DEVELOP CRITICAL THINKING SKILLS AND SCIENCE PRACTICES IN 3RD-5TH GRADE

A Plan B Project

Project Background
Can picturebooks be used to teach science in the classroom?
What I Did

- Literature Review
  - Picturebooks
  - Genre
  - Cognitive Science
  - Pedagogy
  - Narratology
  - Critical Thinking
  - Visual Theory
  - National Science Standards
  - The Nature of Science
  - How to select and use books effectively

- Evaluation Template
- 10 books evaluated
- Selected bibliography

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<th>Resources</th>
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Informational Elements

Aesthetic Description

NGSS
  - Disciplinary Core Ideas

NGSS
  - Science and Engineering Practices

NGSS
  - Crosscutting Concepts

Common Core

Classroom Uses

Key:

- Book Information
  - Content
  - Visual Elements

- Standards
  - Uses
The Importance of Science for Young Ages

High School Career Interest
Coyle, 2005

Disinterested in Science 80%

Interest in Physical Science
Baram-Tabbani & Yarden, 2005

Children under 8 yrs
Older children

(Wells & Zeece, 2007)
(Mantzicopoulos & Patrick, 2010)
Relevancy and Context

(Monhardt & Monhardt, 2006)
(Helterbran & Strohler, 2013)
(Carr et al., 2001)
(Barclay et al., 2012)

Star Stuff: Carl Sagan and the Mysteries of the Cosmos, Sisson
In the yard, pieces appeared.
He noticed treasures in the tall grass.
A tractor had some pipes.
And bearings and bolts that required every muscle to remove.

"Bongo" took charge of the bricks and spokes.
He held up his piece.
But as William dragged his metal house,
people called out,
"The boy is mad. Only crazy people play with trash!"

*The Boy Who Harnessed the Wind,*
Kamkwamba, Mealer, & Zunon
Science Practices: Iteration

- “Hermeneutic analysis” (Nikolajeva & Scott, 2006)
Visual Literacy

- Rise of screen-based cultures and multi-modal interactions increases the importance of visual understandings (Bishop & Hickman, 1992)
Illustration

- **More complex understandings** (Manifold, 2000)
  - Cognitive, affective, cultural understandings (Walsh, 2003)

- **Science communication** (Yore, 2004)

Visual Communication

Each day I shine on earth and
warm the air. The warm air rises.
Cooler air pours in and makes the wind.

Swish! Swoosh!
The wind pushes blades
of turbines round and round,
spinning my energy to generators,
which make electricity.

Electricity pours into
copper wires and flows out to
your towns and cities.
Text Literacy

Elementary Instructional time

- Science: 10%
- Other Disciplines: 90%

(Kurtz & Bartholomew, 2012)
(Broemmel & Reardon, 2006)
(Allier, 2004)

Science Terminology + Reading Comprehension = Increased discussion of understandings

(Price & Lennon, 2009)
Still, people are rarely hurt by creative eruptions because they can outrun, or
outswim, them. In fact, we inch up as close as
we can to these eruptions—even underwater—
to watch the landscape changing.

Scientists and underwater robots to three feet from
submerged volcanoes, observing salp and yellow long
plumes from the vent, warning the air tends to be toxic.
Volcano scientists ride up into the boiling lava in yellow and red
glue to an island explosion.

Hikers climb to base of Mount Kilauea, watching the
smoldering lava flow, witnessing the warning of new peaks
being made, watching as a volcano evolves itself.
Critical Thinking Skills

- Differences in critical thinking skill development by the end of 4th grade (Kettler, 2014)
- Narrative = more efficient integration of new information into existing schema (Schank, 1995)

![Diagram showing the relationship between Critical Thinking Skills, Cognitive Ability, Knowledge and Intelligence, and Schema.](Diagram)

Narrative = Critical Thinking Ability
Critical Thinking Skills

- Reading is highly individual (Williams, 2007)
- Illustrations evoke cognitive, affective, & cultural understandings (Walsh, 2003)

Questioning + Reflecting = Progression of Science
Challenges

On Saturday he ate through one piece of chocolate cake, one ice cream cone, one pickle, one slice of Swiss cheese, one slice of salami, one jellybean, one piece of cherry pie, one sausage, one cupcake, and one slice of watermelon.

[Hug, 2010]
[Trundle & Troland, 2005]
Selecting appropriate books

Where to begin?
Teacher’s Choices, (IRA and CBC)
Outstanding Science Trade Books for Students K-12, (NSTA)
Notable Children’s Book List (ALA),
Robert F. Silbert Informational Book Award
Orbis Pictus Award for Outstanding Nonfiction
Washington Post Annual Children’s Book Guild Non-fiction award
Caldecott Medal

- Accurate and appropriate
- Use of science terminology

- Illustrations contribute as opposed to duplicate
- Visually appealing and engaging

- Positive
- Accessible and relevant
- Lack of stereotypes
Product

- Evaluation Template
- 10 books evaluated
- Selected bibliography

<table>
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<tr>
<th>Title</th>
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Key:
- Book Information
- Content
- Visual Elements
- Standards
- Uses
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<thead>
<tr>
<th>Life Science</th>
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| *Feathers: Not Just For Flying*  
  By Melissa Stewart, Illustrated by Sarah S. Brannen  
  Charlesbridge, 2014 |
| *The Salamander Room*  
  By Anne Mazer, Illustrated by Steve Johnson  
  Knopf, 1991 |
| *The Drop in My Drink: The Story of Water on Our Planet*  
  By Meredith Hooper, Illustrated by Chris Coady  
  Viking, 1998 |
| *How To Clean a Hippopotamus*  
  By Steve Jenkins and Robin Page  
  Houghton Mifflin, 2010 |

<table>
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<tr>
<th>Earth Science</th>
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| *Star Stuff: Carl Sagan and the Mysteries of the Cosmos*  
  By Stephanie Roth Sisson  
  Roaring Brook Press, 2014 |
| *Volcano Rising*  
  By Elizabeth Racch, Illustrated by Susan Swan  
  Charlesbridge, 2013 |
| *Nobody Particular: One Woman’s Fight to Save the Bays*  
  By Molly Bung  
  Henry Holt and Company, 2000 |
| *Everybody Needs a Rock*  
  By Byrd Baylor, Illustrated by Peter Parnell  
  Charles Scribne’s Sons, 1974 |

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Conclusions

- Creative opportunities for teachers
- Boosting interest in science
- Diversity of thinking styles drawn to the sciences
- Building a new generation of problem-solvers
Works Cited

Works Cited


