Real scientists argue: Bringing science and engineering practices to life through trade [picture] books

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This is a new style of article, aiming to add some useful background to readers interested in reading and reviewing suitable educational picture books, putting into context how such books can enhance science learning for young children.

Abstract

Margaret Knight designed solutions. Sarah Campbell asked questions. Thomas Edison and Nikola Tesla argued. What do these people have in common? They are all scientists whose depictions in trade books [for non-US readers, 'trade books' roughly translates to 'picture books'] can provide real-life examples of science and engineering practices, particularly those identified within the Next Generation Science Standards (NGSS Lead States, 2013). Although these specific practices are aligned with the US-based NGSS, they are standard practices within the field and therefore serve as meaningful ways to bring scientists and what they do into focus within elementary [primary] classrooms.

Many elementary teachers integrate science and literacy to support science content acquisition. The use of trade books to foster students' understanding of the nature of science is also supported (Kruse & Borzo, 2010). Similarly, when teachers share books about scientists' inventions or quests for understanding, students can be inspired (Brassell, 2006). By sharing the influential stories of both citizen and career scientists through trade books, teachers can provide models that help their students to contextualise practices such as designing solutions and asking questions.

For each of the eight *NGSS* Practices, we have identified two books that provide real-life examples of people engaging in that particular practice. We relied on Rodger Bybee's (2011) explanations of each practice to provide a brief synopsis; for a more in-depth look at each practice, readers may refer to the original *NGSS* document. When selecting the books, we looked at not only the potential for links with the *NGSS* Practices, but also aspects pertaining to science content and literacy. Each book we selected was reviewed for the following four features: scientific accuracy, visual features, end pages, and engagement potential.

- *Scientific accuracy*. We focused primarily on award-winning books, as they were already vetted for quality. Most of the books we selected were recognised as an NSTA/Children's Book Council's Outstanding Science Trade Book.
- *Visual features*. We looked for photographs, lithographs, and artistic representations that meaningfully supported the written text.
- *End pages*. When included, we examined aspects such as the author's note, glossary, references, timelines, and other features to determine how they extended the main text.
- *Engagement potential*. In reviewing books, we began to recognise that some were 'cut and dry', with an emphasis on facts, dates and details. Other books were more prosaic, conveying the wonder of invention and exploration. While fact-laden books have a place in the classroom, we selected books that would be engaging to either a listener or reader.

A list of the books is shown in Table 1. We have included suggested reading levels and ideas for extending the use of the books for common activities based on the practices. While we've listed

Table 1: Overview of biographical trade books of scientists.

Science and Engineering Practice	Title	Author	Suggested Read Aloud Level	Special Features	Extending the book
Asking questions	Blockhead: The Life of Fibonacci	J. D'Agnese	P, I, M	Afterword; In-book Information "Hunt"	Observe various examples of the Fibonacci sequence in nature, such as on pinecones or flowers
	Wolfsnail: A Backyard Predator	S. Campbell	P, I	Wolfsnail facts; Glossary	Research the feeding patterns of various invertebrates
Developing models	Honda: The Boy Who Dreamed of Cars	M. Weston	I, M	Afterword	Design cars with interlocking building systems and test for speed
	Into the Deep: The Life of Naturalist and Explorer William Beebe	D. Shelton	I, M	Author's Note; Beebe quotes; Glossary; Resources	Design boats from material such as straws, rubber bands and craft sticks to hold a certain number of pennies
Planning investigations	For the Birds: The Life of Roger Tory Peterson	P. Thomas	I, M	Author's Note; Selected Bibliography; Roger Tory Peterson Institute info	Create bird feeders to attract certain species and document the various species
	The Dolphins of Shark Bay	P. Turner	I, M*	Captioned photos throughout; Afterword with more dolphin information; Updates on research;	Determine the effectiveness of various tools to pick up material, such as modeling bird beaks
Analysing and interpreting data	The Tapir Scientist: Saving South America's Largest Mammal	S. Montgomery	I, M*	Captioned photos throughout; Spreadsheets, graphs, & charts; Epilogue; Selected Bibliography; Index	Collect observational data on schoolyard species or classroom pets and determine patterns
	Farmer George Plants a Nation	P. Thomas	I, M	Timeline; Washington's thoughts on slavery; Information about Mount Vernon; Resources	Compare effects of different soil on seed germination and growth

Table 1 cont: Overview of biographical trade books of scientists.

Science and Engineering Practice	Title	Author	Suggested Read Aloud Level	Special Features	Extending the book
Using mathematics	Odd Boy Out: Young Albert Einstein	D. Brown	I, M	Author's Note; Bibliography	Investigate the mathematics of music, such as creating pitches made when tapping glasses of various amounts of water
	Close to the wind: The Beaufort Scale	P. Malone	I, M	Technical drawing of a typical man-of-war; Glossary, Brief biography of Francis Beaufort	Create wind flags and develop scales to qualitatively compare wind speed
Constructing explanations	Rare Treasure: Mary Anning and Her Remarkable Discoveries	D. Brown	P, I. M	None	Match fossils imprints with animal characteristics to infer species
	The Boy Who Invented TV: The Story of Philo Farnsworth	K. Krull	I, M	Author's Note, Additional Resources (books, websites, & other media)	Observe newsprint with magnifiers or microscopes to see how the images are formed with dots
Engaging in argument	Temple Grandin: How the Girl who Loved Cows Embraced Autism and Changed the World	S. Montgomery	I, M*	Specialized end papers; Foreward by Grandin; Diagrams; Advice from Grandin; Additional resources	Design containers to protect eggs dropped from various heights
	Electrical Wizard: How Nikola Tesla Lit Up the World	E. Rusch	I, M	Detailed Notes on rivalry with Edison; Scientific info about electricity, Selected bibliography; Suggestions for further reading	Create series and parallel circuits and compare bulb brightness
Communicating information	The Man Who Named the Clouds	J. Hannah & J. Holub	P, I, M	Weather Journal; Photographs of primary source documents; Cloud photo glossary; Additional resources	Create a weather blog with photos and classifications

Table 1 cont: Overview of biographical trade books of scientists.

Science and Engineering Practice	Title	Author	Suggested Read Aloud Level	Special Features	Extending the book
Communicating information cont.	The Flower Hunter: William Bartram, America's First Naturalist	D. Ray	P, I	Afterword; Photo of a Bartram engraving; Author's Note; Bibliography	Create a field guide of schoolyard trees
Multiple	Star Stuff: Carl Sagan and the Mysteries of the Cosmos	S. R. Sissons	P, I, M	Author's Note; Bibliography; Source Notes	Record observations of the Moon over a period of time

P = Primary grades, I = Intermediate grades, M = Middle grades

* Teachers should select specific sections to share rather than reading the entire book aloud due to the extensive text.

books under specific practices, the books can address multiple practices just as the practices themselves can overlap.

Asking questions and defining problems:
Blockhead: The Life of Fibonacci by D'Agnese blends known information about Fibonacci with conjectures about his early childhood based on his inquisitive nature. Questions that the young Fibonacci might have asked about patterns in nature while gazing out his window, along with his eventual discovery named after him, can inspire young students to more carefully observe and question what they observe. Citizen scientist Campbell depicts her quest to determine the various characteristics of a creature in her yard in *Wolfsnail: A Backyard Predator*. As she details in her book, she uncovers that this particular Mississippi snail is actually carnivorous. Close-up photographs of the wolfsnail also make this book a terrific resource for learning about predatory-prey relationships. The author's website includes a short video of a wolfsnail eating.

Developing and using models:
Weston's *Honda: The Boy who Dreamed of Cars* opens with young Honda in Japan, where he had spent over a year sweeping and cleaning a garage just so he could have a chance to become a mechanic. He finally has the opportunity to develop his engineering ideas, working first to improve the metal rings that surround pistons and later using his expertise to develop a better bicycle. The Afterword section documents his tireless efforts to bring his dreams of building cars and other vehicles to life. *Into the Deep: The Life of Naturalist and Explorer William Beebe* by Sheldon describes the life of a man who was always interested in nature and the creatures within it. The book depicts problems associated with the prototypes of Beebe's eventually successful bathysphere, which took underwater exploration to new levels.

Planning and carrying out investigations:
Many of us are familiar with Peterson's guides, and Thomas' *For the Birds: The Life of Roger Tory Peterson* provides readers with a glimpse into how he first became interested in bird watching. As a young student, he was encouraged by a teacher who started a Junior Audubon Club at his school. The book describes how he used both photographic images and observational notes, samples of which are included in the illustrations.

Turner's *The Dolphins of Shark Bay* showcases the circuitous paths that scientists often take when conducting field studies. Observations of dolphin behaviour led to more questions, which in turn changed the focus of their investigations. In this case, the behaviour of 'sponging' by dolphins shifted the investigation carried out by these naturalists. This book is filled with captioned photographs and richly detailed descriptions of the procedures that these dolphin scientists have carried out over the past 25 years.

Analysing and interpreting data:
Montgomery's *The Tapir Scientist: Saving South America's Largest Mammal* contains a unique surprise: research data displayed in tables, graphs and spreadsheets. Records ranging from the relationship between time of day and tapir sightings to success rates of box trap captures allow readers to examine actual data samples. The importance of analysing and interpreting data is equally prevalent in Thomas' *Farmer George Plants a Nation.* Many recognise Washington as the first President of the US, but most will be surprised to know that he made significant contributions to the field of agriculture. His meticulous and methodical approach to mixing various types of manure into soil to determine which was most effective for planting various seeds is just one example of how he engaged regularly with agrarian-based data analysis. His quotes are interspersed throughout the text, and the End Notes provide a timeline of his life.

Using mathematics and computational thinking:
Brown's *Odd Boy Out: Young Albert Einstein* provides an interesting glimpse into the somewhat troubled life of Einstein. Despite his brilliance, he struggled to find success in school. Both the illustrations and the words support the idea that Einstein thought differently from most. Another mathematics-related book is Malone's *Close to the wind: The Beaufort* Scale, which provides a fictitious account of a voyage on a man-of-war ship by William, a 12 year-old boy from the 19th century. Woven throughout the narrative is Francis Beaufort's contribution to the maritime world: the Beaufort Scale. The Beaufort Scale for wind ranges from 0-12 and serves as an example of scaling qualitatively rather than quantitatively. A biography of Beaufort is included in the End Notes.

Constructing explanations (for science) and designing solutions (for engineering):
In *Rare Treasure: Mary Anning and Her Remarkable Discoveries*, Brown tells the story of a young British girl who withdrew from school at the age of 11 and spent her life finding and explaining fossils of long extinct animals. From the ichthyosaur fossil that she found at the age of 12, to the pterodactyl fossil that she found at the age of 29, discovery was never enough; she always attempted to make sense of what she found by reading scientific books of the day. Her efforts were rewarded with wide recognition and respect throughout Europe. Krull's *The Boy who Invented TV: The Story of Philo Farnsworth* is an example of a little-known scientist who used nature as an inspiration for an engineering solution. Farnsworth read everything he could about television and the failed prototypes and ideas that did not make it to fruition. When he was ploughing his family's potato fields, he envisioned creating pictures by a means similar to the parallel lines of planted fields. The book describes Philo's trials and tribulations to translate his engineering vision into reality, along with the difficulties of patenting an invention.

Engaging in argument from evidence:
Montgomery's *Temple Grandin: How the Girl who Loved Cows and Embraced Autism Changed the World* explores Grandin's life as both a scientist and a person with autism. Though Grandin had to argue for equal access throughout her life, the most compelling narrative surrounds her quest to create a humane dip-vat pool. She identified why cows were literally scared to death and designed a new dip-vat that would make them feel more secure, and had to argue her point to prove that her design was superior. Rusch's *Electrical Wizard: How Nikola Tesla Lit up the World* is a biography of Tesla and his journey to build machines based on alternating current (AC). The friction between Tesla and Thomas Edison, the primary advocate of direct current (DC), is an important component of the story. Tesla had to argue against the popular theory of the day in order to secure the honour of powering the Chicago World's Fair. A detailed Author's Note provides even more details on the rivalry between Tesla and Edison.

Obtaining, evaluating and communicating information:
Hannah and Holub write about little-known Luke Howard in *The Man who Named the Clouds*. Born in the 18th century, young Luke was fascinated by clouds, but found it hard to describe his cloud observations. He decided to develop a means of classifying clouds using Latin names. His organisational method is still the basis of our current cloud classification system. The book includes not only photographs and illustrations of clouds but also examples of weather journals written in child-friendly formats. Ray's *The Flower Hunter: William Bartram, America's First Naturalist*, also includes text formatted as a journal. The story

of this naturalist is told in first person through the eyes of William as he travels with his father, a noted botanist, around what would become the southeastern part of the United States. The Afterword includes details on the travels, accomplishments and writings of this father and son pair, as well as a reproduction of one of William's hand-coloured engravings of the tree that they discovered together.

Final notes

Though we have identified the previous books according to one specific *NGSS* Practice, we have also noted that many of the books could support more than one. *Star Stuff: Carl Sagan and the Mysteries of the Cosmos* by Sisson (2014) starts by following an imaginative and curious young Carl to the 1939 World's Fair, where he is amazed by the technology and inspired to begin asking questions about space, and stars in particular. It explains how he studied to become a professor and worked with others to collect data from the planets nearest to us, and depicts how he used television to communicate information to the general public.

Finally, Sisson includes information on how Carl planned and carried out his idea to include multiple messages from our world to others in the form of sounds, music, pictures and more, via Voyagers 1 and 2 as they travelled through space. Thus, four *NGSS* practices are clearly depicted in this well-written picture book biography, appropriate to read aloud to just about any age level.

Although we have identified specific books, we encourage teachers to utilise not only these but also other books, to provide real-life depictions of science and engineering practices in action.

Bringing these practices to life through the stories of both citizen and career scientists can demonstrate the integral role of these practices.

References

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