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AC 2011-1762: INTEGRATING CHILDREN'S LITERATURE INTO OCCUPATIONAL LEARNING ABOUT ENGINEERS

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Integrating Children's Literature into Occupational Learning about Engineers

At a very young age, a child has the ability to formulate ideas regarding the occupation of a lawyer, a nurse or even a doctor. Prior to even entering the workforce, children process all the information around them to form aspirations and define expectations regarding their place in the world in a process called anticipatory socialization.¹ This socialization process is integral for adolescents to mature into working adults, and make their place into society.¹

The fictional characters in books act as role models, influencing wishful identification of the occupation of their favorite character.² An example of wishful identification is evident during the Halloween season, when children dress up in costumes of their favorite television and literary idols. Wishful identification is the child's projection into the role of a character, such as Harry Potter. The familiarity of certain occupational markers can then translate into interest as a potential vocation. Therefore if positive role models in engineering were presented in books, increased wishful identification of engineers could result.

However, if children are not introduced to engineering at a young age, they might not develop an interest in it. Studies have shown that most children have limited information regarding engineers, and the lack of knowledge can often perpetuate into adulthood.^{3,4} In a study by Cunningham et. al (2005) they found that children in grades K-5 often associated engineering with auto mechanics and construction workers.³ The general lack of knowledge can perpetuate further problems, such as the continuance of misconceptions, and decreased interest in engineering as an occupation.

There is general concern regarding the numbers of engineers going into the field, since it is expected that demand for engineering expertise won't be met with current graduation rates.³ In response, several K-12 programs have been developed to increase exposure to engineering, normally in a formal setting.^{5,6} While well-intentioned, the faltering graduation rates of engineers from suggest these programs are falling short of bolstering the country's supply of future engineers, and further action must be taken to maintain a global engineering presence.³ Rather than aim at the preparation and retention of older students, the solution may lie with a younger crowd (ages 3-6), since development during formative years has implications towards development of misconceptions and future career choices.⁷

In recent years several professions have looked towards storybooks as a way of communicating occupational knowledge. For example, the short supply of nurses resulted in innovative strategies to encourage more people to enter nursing careers, by developing storybooks to engage a younger audience.⁸ Storybooks provide an interactive process where the child interacts not only with the words and pictures on the page, but with the reader in an inquisitive manner.⁹

Storybooks have previously been shown to be a useful tool in formal learning. In a school setting, children's books have been shown to impact kindergartener's mathematical achievement when produced in tandem with a mathematics unit.¹⁰ Additionally, storybooks have been shown to facilitate discussion between diverse populations.¹¹ For use in formal education, the Engineering is Elementary (EiE) project has produced research-based storybooks for curriculum

guidance in grades 1-5. These books follow a young protagonist during a design challenge in which they are mentored by an older engineer.¹²

Additional exposure to engineers in literature on an informal basis is needed; however an assessment of the current literature base is required to look at future impact. A review of children’s literature (ages 8-12) in Australia only found a single book relating to engineers, showing the lack of presence for engineering literature.¹³ This study aims to analyze the current literature on engineers for even younger children (ages 3-6) to determine potential routes for both informal and formal learning. Specifically of interest are how engineers are portrayed in current children’s literature, what messages are presented about engineering and what is the potential for misconceptions to be perpetuated?

Methods

A search of children’s literature was completed using several different online sources using the keyword “engineer” within the confines of juvenile literature. Further differentiation included fictional storybooks intended for ages 3 to 6 years. Searches were limited to books and didn’t include music, articles or videos. To eliminate misrepresentations within the database, each entry was individually examined and coded for age level and application to engineering. Books were not included in the analysis if the content didn’t contain references to engineers or engineering in the subject headings, as designated by Library of Congress. Multiple databases were used to cover a broad expanse of written material and to assess availability of books to general public (Table 1).

The WorldCat database is the most comprehensive online source for catalogued literature for the entire world. Since the keyword “engineer” is more specific than a broad category such as “science”, online searches were sufficient to delineate books of this nature. Additional databases were used to include independent published materials that are not included in the WorldCat database.

Table 1. Databases for search of engineering books

Type	Locations
Bookstores	Amazon.com, Barnes and Noble, Powell’s, Borders
Libraries	Tippecanoe County, Chicago Public Library,
Databases	WorldCat, Worlds of Words

This study focused on fictional storybooks, which are a mixture of illustrations with minimal text (< 1 page compiled), for those in young childhood (aged 3-6 years). It was expected that this type of book would be the most widely read for this age group due to limited time commitment and engaging stories. Also since the storybooks are fictional, they help to illuminate certain inherent misconceptions about an occupation, especially if the author themselves is not an engineer. Biographies and non-fiction books were excluded from the study as they are often beyond the reading comprehension of this age level (for books in this range excluded from the study please see Appendix A). The Engineering is Elementary books (n=18)

were not included as they are primarily intended for in-class use and are not intended for the specified age range in this study.¹² The books were analyzed for (1) common misconceptions in engineering, (2) thematic analysis of messages, and (3) implications for learning in and out of classroom. Additionally, the top ten children's picture books (based on record sales) were analyzed for potential application to engineering.

Findings

In the Worldcat database¹⁴ using engineer as a keyword, a total of 605 books were classified. A majority of the books were non-fiction (n= 386) and biographical (n = 115) books. Popular historical engineering figures included Herbert Hoover, Thomas Edison, and Henry Ford. Of these, only 41 books had the word engineer in the title, though some were mislabeled due to inconsistencies in the database (Figure 1). Particularly, audio and paper engineers associated with production of sound and pop-up books slightly inflated the numbers (n=4). Over half of the books were linked to trains (n =22), showing a potential link as to why young children associate engineers with railways. Of the eleven stories pertaining to engineers, only three were suited within the parameters of the study for the younger age group. The books for older children were delineated by length (> 50 pages), lack of illustrations and complexity of storylines. Additional searches used a combination of the parameters and variation of keywords to exhaust the database. Cross validation of the database occurred through online bookstores and local libraries (Table 1).

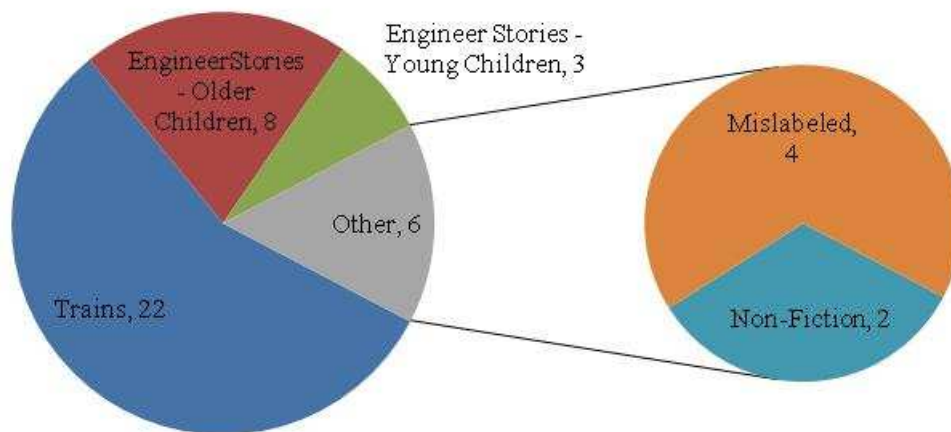


Figure 1. Distribution of books with engineer in the title showing a majority of books associated with trains. Only three books were within study parameters.

In total 6 fictional storybooks were found pertaining to engineers within the study boundaries. Three out of the six have limited access to general populations as they are collectables found in university libraries^{19,20} or in one case only within the United Kingdom¹⁸. The remainder of the books were self-published in small runs.^{15,16,17} Access to these books is minimal, as seen by the nominal amounts in nationwide library circulation, ranging from 0 to 55 books available in the system (Table 2). In comparison, the book *The Hungry Caterpillar* by Eric Carle has over 30 million copies in print, with over 5,000 books in library circulation in the United States.²⁴ The lack of books made analysis difficult, but showed the lack of engineering titles in current children's literature.

Table 2. Contemporary books with engineering as a focus, with total number of available copies in library circulation (# of books available) in the U.S.

Title	Author(s)	Year	Type	Circulation
<i>Engineering Elephants</i> ^{#,15}	Emily Hunt & Michelle Pantoya	2010	Storybook	1
<i>Caleb: The Mouse Engineer</i> ^{#,16}	Clifford D. Cope	2009	Storybook	0
<i>Rocks, Jeans and Busy Machines</i> ^{#,17}	Alane & Raymundo Rivera	2009	Storybook	10
<i>My Dad's an Engineer</i> ¹⁸	Richard Davey & Katie Green	2006	Storybook	3 (only in U.K.)
<i>Sancho, Pronto & the Engineer</i> ¹⁹	Make Keats & Alex Cervantes	1976	Storybook	55*
<i>Brownie: The Engineer of Beaver Brook</i> ²⁰	Allen Chaffee	1925	Storybook	11*

* Majority listings available in university special collection libraries (minimal public library access).

Books used in analysis

Book Descriptions

Caleb: the Mouse Engineer by Clifford D. Cope is about a mouse that uses physics to outwit a manipulative iguana.¹⁶ The Iguana wants to trick the mouse into getting a coconut from tree, but in turn the mouse tricks the iguana by implying that a coconut on an angled tree would fall at an angle instead of straight down. However, the physics of the situation is not explained. Cope is an anthropologist with a military background who wanted to write a story for his grandson about math and science.

Rocks, Jeans and Busy Machines is a joint effort by married couple Alane & Raymundo Rivera.¹⁷ Both have backgrounds in civil and electrical and biomedical engineering respectively. In their book they introduce the “engineering kids”, a group of multicultural boys and girls that are interested in engineering. Violet, the main character in this book, explains some part of a construction site – relating some engineering concepts to something relatable to children. For example, when explaining about concrete she talked about how sand stuck better with water. Additionally, at the end of the book there was a reflective piece on what the engineering kids learned to help to reinforce the engineering concepts.

The third book was developed by mechanical engineering professors Emily Hunt and Michelle Pantoya, and is titled *Engineering Elephants*.¹⁵ They use rhyming mechanics and unique comparisons to show what types of artifacts engineers work with. In several instances they use actual vocabulary that could be way above the developmental level of the targeted audience, such as nano-threads, composite and aerodynamics. They also were the only book to have an actual representation of a fictional engineer who was wearing a lab coat.

Table 3. Break down analysis of engineering storybooks for children aged 3-6 years.

	<i>Engineering Elephants</i> (2010) by Hunt & Pantoya ¹⁵	<i>Rocks, Jeans & Busy Machines: An Engineering Kids Storybook</i> (2009) by Alane & Raymundo Rivera ¹⁷	<i>Caleb: The Mouse Engineer</i> (2009) by Clifford D. Cope ¹⁶
Written by an Engineer	Yes (Ph.D. ME)	Yes (M.S. C.E.)	No
Main Character(s)	Elephant (non-gendered), sometimes depicted with a girl with curly hair (back of head only)	Violet – white Caucasian girl, very know-it-all, tucked –in button down shirt, belt & jeans Pedro – button down shirt and slacks (there are other engineering kids that are multiracial)	Iguana (bad guy) and mouse (good, supposedly a “engineer”)
Cover	Elephant in racecar w/ surfboards and turbines	Violet with concrete truck in background	Mouse waving with iguana lurking behind a tree.
Story	Engineers do not make ladybugs, volcanoes or eggs, but they do design surfboards, windmills and rocket ships.	On way to a park two friends discover a construction site and learn about how concrete is made and that engineers design buildings to be strong and safe	Iguana wants to trick the mouse into getting a coconut from tree, but in turn the mouse tricks the iguana with physics (imply that coconut on an angled tree would fall at a angle)
Applicable to young audiences	Vocabulary too difficult, but the repetitive questions draws them in.	Very colorful, story transitions well.	Pictures not friendly to young kids, text could flow better (not that engaging).
Vocabulary	Momentum, drag, aerodynamics, synthetic, composite materials, turbines, molecules, chemicals, mixture, solid fuels, temperature transfer, nano-threads	Construction, machines, concrete truck (explanation), design.	Angle
Engineering Principles	Different types of artifacts that engineers could work on	Making connections that engineers design buildings to be “strong” to withstand different situations (loads → strength). Relate to different structures (building, bridge, playset) as well as safety.	No matter what angle anything falls from, it will still fall straight down (does not explain why).
Engineer (person)	In lab coats, female w/ computer in background	None	None
Message	Math and science are tools for engineering	Engineering is all around.	Story with math and physics in it.

Misconceptions

Misconceptions about engineering can range from big concepts such as all engineers drive a train, to small ideas such as engineers wear pocket protectors. Oftentimes misconceptions in books are derived out of the author's lack of knowledge regarding engineering. In the literature in this study several misconceptions were perpetuated. One potential misconception found in the storybook by Cope, inferred that engineers are tricksters who use their knowledge in potentially harmful ways (e.g. the iguana gets knocked out).¹⁶ This is counteractive to the positive message put forth by NAE in that engineers make a difference in the world.²¹

Thematic Analysis

Messages in *Engineering Elephants* included the application of math and science as tools for engineers and the concept that engineers impact the world around them (Table 3). Problem solving ability was evidenced through main character interaction when faced with a challenge as seen in *Caleb: the Mouse Engineer*.¹⁶ *Rocks, Jeans & Busy Machines* showed that engineering is all around by connecting a construction site to the beach, foundations for a building, and monkey bars.

Popular Storybooks

Due to the limited amount of children's books that explicitly pertained to engineering, ten of the top selling books were analyzed for potential application to engineering principles. The list was derived from overall sales in the United States over the past twenty years. Engineering principles looked for included basic math, problem solving, spatial reasoning and observation skills.

The broader approach looking at children's narrative stories, investigated embedded engineering ideas in popular stories. This examination revealed that several popular children's stories communicated concepts relevant to engineering, although engineering was not explicitly described or discussed. These concepts included problem solving, multiple alternatives, and spatial conceptualization. For example, in *The Giving Tree* by Shel Silverstein, the main character went through several different uses for the same tree, much as engineers sometimes have to use materials for various purposes.²³ This same book could also potentially incorporate basic lessons about sustainability and life-cycle analysis. Some examples of books that have a stronger relation to engineering concepts include the *Magic School Bus and the Electric Field Trip* and *How do you Lift a Lion?* by Robert E. Wells.^{32,33} The *Magic School Bus and the Electric Field Trip* already has a teacher's guide developed for in class instruction.³⁴

Table 4. Top ten bestselling children’s storybooks based on highest sales with observed engineering connections.

Title	Author	Engineering Connection
Where the Wild Things Are	Maurice Sendak	N/A
The Giving Tree	Shel Silverstein	Alternative Uses
Goodnight Moon	Margaret Wise Brown	N/A
Green Eggs and Ham	Dr. Seuss	Problem solving approach using different angles, learning to try different things (alternative solutions)
Cloudy With a Chance of Meatballs	Judy and Ron Barrett	Mentioned how the sanitation department had to do things differently (problem solve)
The Very Hungry Caterpillar	Eric Carle	Counting, build a cocoon (structure)
Alexander and the Terrible, Horrible, No Good, Very Bad Day	Judith Viorst	N/A
Guess How Much I Love you	Sam McBratney	Progressively bigger distances (spatial skills), body manipulation
Pat the Bunny	Dorothy Kunhardt	Different materials have different textures
Love you Forever	Robert Munsch	N/A

One potential drawback to using popular books for learning is that the educator must be cognizant of the connection to engineering. Because the word “engineer” isn’t stated explicitly in these books, there is room for misconceptions to occur, in addition to the missed opportunity to learn about engineering. Development of informational guides to go along with the popular books might be an avenue for increasing the awareness of engineering.

Conclusion

Integrating children’s books with either direct engineer references or even using popular books containing implicit engineering concepts has implications for learning in both formal and informal environments. However, this study shows that there is only a limited amount of narrative books available for this age range (3-6 years), indicating a potential area of development. Further identification with popular books may be an avenue for exploration until more books on this subject become available. Future work will encompass how a developed children’s book will influence children’s views on engineers.

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Appendix A

Table A1. Additional non-fiction books on engineers and engineering that were not within study parameters.

Title	Author(s)	Year	Type	Circulation
The Engineer, or How to Travel in the Woods	Jacob Abbott	1856	Unknown	33
Engineers & Architects	Kang Zhu	2005	Non-Fiction	1
Seven Wonders of Engineering	Ron Miller	2010	Non-Fiction	71
Engineering the City: How Infrastructure Works	Matthew Levy	2008	Non-Fiction	1
Engineering the ABCs: How Engineers Shape Our World	Patty O'Brien Novak	2010	Non-Fiction	5
I want to be an Engineer	Cathleen O'Neill Grace	1997	Non-Fiction	728
You Can Be a Woman Engineer	Judith Love Cohen	1995	Autobiography	0