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Influencing Perceptions of STEM Through the Best STEM Books List

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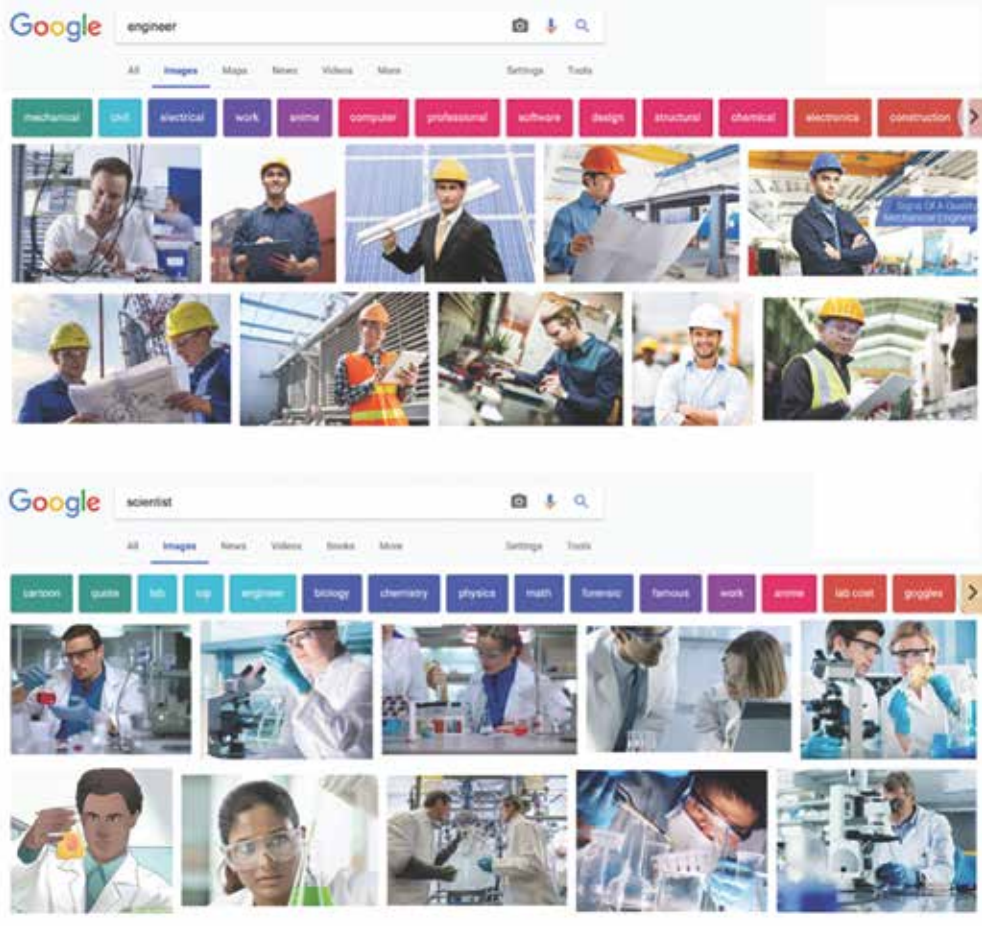
By Scott Bartholomew and Alexia Seymour

One day, while discussing engineering and science as potential career options with a female student, we opened a search engine and typed in "engineer" and "scientist." However, on the first pages of image results, only one female appeared for engineering and only a few females appeared for "scientist" (see Figure 1). This disparity was disturbing—if this student never saw another person like her filling careers in STEM fields, would she ever "picture herself" in those fields?

FIGURE 1

Image search results for "engineer" and "scientist."



As a STEM teacher-educator and a future STEM teacher, this question—and the lack of diversity in the images represented—intrigued us. As we discussed the lack of female individuals in the images, we wondered if it would be possible to shape students' perceptions of STEM careers by presenting them with examples of others who were filling these roles?

FACTORS AFFECTING STEM INTEREST

Research shows the importance of students' interest in and attitudes toward STEM careers is influenced by a variety of factors, especially at an early age. For example, Sadler, Sonnert, Hazari, and Tai (2012) reported that the key factor in predicting STEM career interest within students at the end of high school

was initial interest at the start of high school. Many students decide that STEM subjects are difficult, boring, or unwelcoming—as compared to other subjects—at an early age; for example, many students view science as a challenging and difficult subject that is appropriate for only a select few. Further, many high school seniors used the opportunity to avoid science and math courses as part of their career decision-making and aspirations, and less than one-fourth of students who aspired to enter a science or engineering career prior to eighth grade maintained those aspirations six years later.

Gender has been linked with an interactive effect on attitudes and interest in STEM careers and, although male and female students take K–12 math and science courses at comparable numbers, males are more likely to pursue STEM careers after high school than females, especially in the field of engineering. Further, once in college, female students are less likely than male students to remain in STEM majors, graduate with a STEM degree, or make the transition into a STEM career. Sass (2015) reports that while male students obtain higher academic achievement in STEM subjects compared to females, this difference in achievement may have less to do with their abilities than it does with perceptions—they believe they will do better!"Other research demonstrated that female students have more negative attitudes toward science, math, and related careers—as compared to male students—and that these attitudes becoming increasingly negative with age.

Farland (2006) reported that literature, such as nonfiction trade books, could broaden perceptions of science in young students. Popov and Tinkler (2011) also cited the potential for STEM-centered literature to be influential on young student's attitudes and skills.

Reading texts with STEM themes may be one of the best ways for students to build literacy skills (including how to read, write, and reason with the language and text) while learning STEM content and cultivating dispositions of science.

OUR PLAN: READ STEM BOOKS TO ELEMENTARY SCHOOL STUDENTS

We decided to partner with a local elementary school to investigate the potential for influencing student's perceptions of STEM through literature. Specifically, we hoped that using high-quality STEM books might broaden the perceptions, expectations, and aspirations of students. We chose the National Science Teaching Association and Children's Book Council's (CBC) *Best STEM Books* list as our resource for obtaining books to read (*www.nsta.org/best-stem-books-k-12*). This list—put out yearly since 2017—developed from a collaboration between the American Society for Engineering Education, the International Technology and Engineering Educators Association, National Science Teaching Association, the Society of Elementary Presidential Awardees, and the Children's Book Council and was originally intended as a recommendation of Science, Technology, Engineering, and Mathematics (STEM) topic trade books for librarians, educators, and parents (NSTA 2017). Over time, the responsibility for choosing the "Best STEM Books list" was taken over by the CBC and the criteria for inclusion expanded to include demonstrating practices of science and engineering and the inclusion of elements such as modeling real-world innovation, embracing real-world design, invention, and innovation, connecting with authentic experiences, and showing assimilation of new ideas (NSTA 2020). The yearly winners represent a wide breadth of topics with titles that encourage readers to examine the "thinking stance" of characters—not simply to look at actions and results (NSTA 2019). Books cover a wide range of topics within the disciplines of STEM and include ideas such as inventions, the design process, programming, animals, eye doctors, architecture, and braille.

The school we partnered with, located in the midwest United States, has grades kindergarten (ages 5–6) through fifth grade (ages 10–11), with a total of 592 students and approximately 20–30 students per class. Following administrative and IRB approval, we partnered with several teachers across grades to implement a simple study involving student's perceptions of STEM. Importantly, all the teachers we contacted were recommended by the administration and all were female (there are only a few male teachers in the entire school); additionally, the undergraduate student researcher is female, and the university teacher educator is male. Following consent to participate from teachers, we contacted and obtained assent and consent from students to participate as well.

Our intervention was simple: we visited each class one time a week for eight weeks; during our visit, we (the undergraduate student researcher and/or the university teacher educator) read aloud two different books from the *Best STEM Books List* to students for 30 minutes. Prior to beginning our research, we prepared a simple questionnaire that we gave to the students on the first visit and then again on the last visit (Figure 2). This questionnaire represents a modified version of the S-STEM Survey from the Friday Institute and was used to gauge students' impressions of STEM fields. As many of our younger stu-

dents could not read or struggled with reading, we used a simple "Thumbs up," "Thumbs down," or "?" answer option for each question and all questions were read aloud to students.

Following the questionnaire, we spent six weeks reading to the students in each classroom. Each week's reading consisted of two books with an intentional emphasis on choosing one book with a male protagonist and another with a female lead character. The students seemed to especially enjoy that the books had a real person as the main character and many times the students were surprised that a real person actually accomplished what was relayed in the book (i.e., Philo Farnsworth inventing the television or Temple Grandin discovering better ways to work with animals). After each reading, we asked the students a few questions about the books such as: "What was this book about?" "What did the main character do?" "Do you think you could do that?" and "What STEM ideas or concepts were present in this books?"

The final week (week 8) of the readings project involved the questionnaire again and then, following repeated requests from the students, we engaged all the students in a hands-on activity/experiment inspired by the readings. Given the nature of these books, it was common for many activities, ideas, and experiments to be included (e.g., after finishing the questionnaire with the first-grade students, we completed an activity with students using Coke and Mentos as shown in the book *Ada Twist Scientist)*. Noting the interest of students in these activities, we decided to emphasize various activities from the books with the classes and asked students to purposefully engage in practices of science and engineering (e.g., asking questions and defining problems) while we did so. A list of *Top STEM Book* titles, some of the activities we used with students following the reading, and associated concepts and practices are included in Table 1.

FIGURE 2

Student questionnaire.

The next questions are about science. Science is the study of the natural world.

I am good at science	👎	👍	?
I like science	👎	👍	?
Boys are good at science	👎	👍	?
Girls are good at science	👎	👍	?
When I grow up I think I could do a job that uses science	👎	👍	?

RESULTS AND TAKEAWAYS

Following the readings, we entered all student responses, from both the pre- and post-questionnaire, into statistical software for analysis. The tests revealed that, for the most part, the pre and post answers from students were not significantly different. This was true regardless of grade level or classroom. However, we noted one interesting exception: the proportion of *female* students showing positive changes in science from pre to post was significantly larger than that of male students. Specifically, female student's responses to *"I like Science," "I am good at Science,"* and even *"Boys are good at Science"* all had significantly more positive changes than for male students.

In addition to this statistically significant finding, we also noted several anecdotal findings during our visits.

In many cases there appeared to be a strong gender-based competitive spirit in the way students responded to questions: i.e., regardless of grade-level or classroom when the statement *"Boys are good at _____" or "Girls are good at _____"* was read, there was audible snickering, discussion among students, and sometimes even a quick debate as to which gender was "better" at the STEM area. This was universally a "boys versus girls" debate with each gender advocating for their own. This also happened despite ex-

plicit instructions from teachers, and us as guest researchers, to avoid these things. In many cases students would shield their answers from view when it came to these questions (especially if they had the opposite gender sitting next to them) and there was considerable giggling following the response time for students when it came to these questions.

Many students had eye-opening experiences during the readings. We noted that this appeared to be especially true for female students who sometimes cheered when a book with

TABLE 1

Best STEM Books list for 2020.

Book	Author	Grade Level	Activity	NGSS Concepts	NGSS Practices
The Marvelous Thing That Came From a Spring	Gilbert Ford	K–2	Testing a Slinky out on a staircase	Cause and Effect	Developing and using models
Iggy Peck, Architect	Andrea Beaty	K–2	Build a bridge out of toothpicks and marshmallows	Structure and Function	Constructing explanations and designing solutions
My Journey to the Stars	Scott Kelly	1–3	Build a rocket ship out of playdough	Interdependence of Science, Engineering, and Technology	Planning and carrying out investigations
What Does It Mean To Be Entrepreneur	Rana DiOrio	K–2	Create your own logo or invention	Structure and Function	Obtaining, evaluating, and communicating information
Margaret and the Moon	Dean Robbins	K–2	Create and paint your own constellations	Cause and Effect Systems and System Models	Constructing explanations and designing solutions
Six Dots	Jen Bryant	1–3	Write messages to classmates using Braille dots	Structure and Function	Constructing explanation and designing solutions
SWAP!	Steve Light	K–1	Swapping card game where students start with one card, trade 2 or 3 time to end up with a final card	Patterns	Using mathematics and computational thinking
Ada Twist, Scientist	Andrea Beaty	K–2	Coke and Mentos	Cause and Effect	Asking questions and defining problems

a female character was presented for reading. Reading about female individuals who swam with sharks, invented great things, or changed perceptions of others during their life appeared to have a significant and positive impact on the female students especially.

The reaction of students was different depending on who read. As the lead researcher, I am a male professor of teacher education. Alexia is a female undergraduate student studying teacher education. We noticed different reactions in the students based on who was reading the books—especially prevalent was the connection of female students to Alexia—a college undergraduate student pursuing a degree in a STEM field—during a reading of a book with a female protagonist.

Outside of gender, there are many important traits in STEM book characters that should be considered. For example, race, socioeconomic status, country of origin, language, culture, family makeup, and a host of other factors all tie into children's perceptions of their own abilities, aspirations, and connection to trade book characters. As the books selected for this project were taken from the NSTA Best STEM books list, we are quick to point out that additional and intentional efforts to include a diverse set of characters may have changed the results from this study. However, we see great potential in this simple intervention as multiple characters in the books selected did represent diverse nationalities (e.g., Cho Chang weighs an elephant, Tik Tok Banneker's Clock) and students appeared to connect well with these characters and their experiences.

The books students read, and had read to them, appear to have the capacity to make a difference on their perceptions of STEM. Without this exposure, many students may artificially limit their own potential for future success in a variety of fields. Further, role models—both those in books and those interacting with students—are an important facet of both understanding and shaping student's perceptions of their own capacity for STEM success. The inherently competitive feelings between genders—although not surprising—was both interesting and eye-opening; while our data suggest that female students are more willing to see beyond these feelings, we noted that it may be important for teachers, and other role models, to discuss these topics with students. Perhaps an emphasis on identifying both male and female role models could be beneficial to students.

In conclusion, we present here a *Next Generation Science Standards*–aligned approach to introducing the *Top STEM Books* to elementary students. This simple activity—reading with students a trade book related to a STEM topic and engaging in a hands-on experiment—can help not only relay content knowledge but also expand perceptions of current and future possibilities for all students. Facilitating connections between students and the characters in the books appears to be an important and impactful experience—one that can be potentially magnified when the facilitator (reader) is the same gender as the student. We encourage all teachers to try something similar with their students—the impact of a simple activity like reading a book may be the difference in student perceptions and plans. Action research–based activities can provide clues that help move us toward better approaches for enhancing interest and achievement in students. Perhaps, with time and effort, a search-engine search of "engineer" or "scientist" will display a different set of results. ●

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