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Chapter

Developing Young Scientists: The Importance of Addressing Stereotypes in Early Childhood Education

Donna Farland-Smith

Abstract

Children are born natural scientists. Research has shown they draw less stereotypical images of scientists the younger they are and less school experience they have. This chapter explores stereotypes young children hold of scientists and engineers and how teachers might recognize, address, and combat these stereotypes in the early childhood classroom. From an early age, children receive messages directly and indirectly about scientists, from their parents, media, television, books, and school. The messages they receive help them shape their science identity and test ideas about who can be scientists and what stereotypes exist. Evidence has demonstrated that students are aware of stereotypes and they are able to recognize and discuss stereotypes in a way that broaden their perception of scientists and engineers. To begin the discussion of pedagogical methodologies, the history of drawings of scientists (and engineers) will be discussed. Likewise, these discussions of stereotypes and new awareness can increase career choices including these two fields: science and engineering. Explicit instruction about the stereotypes the stereotypes and implications that follow for early childhood science classrooms will be discussed.

Keywords: stereotypes, elementary science instruction, attitudes and perceptions toward scientists and engineers, nonfiction historical trade books

1. Introduction

How do young scientists develop? What draws some people into science or engineering long before they realize there is something called a “career?” Why are some people, regardless of gender, attracted to science careers and some not? What stereotypes, both explicit and implicit, exist that contribute to one’s ideas and perceptions about scientists? These are some of the questions to be explored in this chapter.

It is important to note that the intention of this chapter is to recognize that all children in early childhood are natural scientists. Two well-accepted ideas about how young children embrace science and interact with the environment come from Reggio Emilia and Maria Montessori. Both approaches support the child as their own scientist, and exploration is key in each of these approaches. The Reggio Emilia

approach is an educational philosophy focused on preschool and early education that is student centered and uses self-directed, in relationship-driven environments. The Montessori method views the child as one who is naturally eager for knowledge and capable of initiating learning in a supportive, thoughtfully prepared learning environment. Regardless which curricula focus, the environment is the third teacher and science is taught in that environment. Thus, children assume the role of scientists naturally.

In the book, *The Last Child in The Woods*, the author, Richard Louv, even cautions against the opposite experience, “If education and other forces intentionally and unintentionally, continue to push the young away from direct experience in nature, the cost to science itself will be high. Most scientists today began their careers as children, chasing bugs and snakes, collecting spiders, and feeling awe in the presence of nature. Since such untidy activities are fast disappearing, how, then, will our future scientists learn about nature?”

However, we know that it is not practical that all children develop into scientists, but rather it is to not turn children off to science careers precisely when they are the most open to it. It appears that the more children go through formalized science in schools, the less they like and enjoy science and think about themselves in science careers. Therefore, the formative early childhood years become even more precious when it comes to lifelong aspirations. For example, we know that girls especially self-select out of math and science careers by age 10, which means what happens in early childhood years is extremely important [1]. While it is generally accepted that adolescents need to begin to think and plan for career choices, this suggests that even long before children are able to express or verbalize which careers may be interesting to them, they are processing information about their possible future.

As young children gather lots of information from parents, media, books, and schools, they collect, reject, and store ideas about scientists conceptually. For these reasons, asking children to Draw-A-Scientist has become an accepted method to provide a glimpse into how children represent and identify with those in the science fields. This chapter looks broadly at the critical aspects involved in on the different phases of one’s academic life in order to observe how early childhood students take a variety of experiences with scientists and internalize them into their own science identities. Some of the central experiences discussed are perceptions of scientists at crucial developmental times in relation to formal schooling. For example, the biographies of Thomas Edison and Benjamin Franklin suggested that the very foundations of modern industry and design grew first in the waters and woods and farmlands of childhood [2]. This chapter will now discuss how to recognize stereotypes in science, what stereotypes mean, and how to combat these stereotypes.

2. How to recognize stereotypes about scientists in young children

Stereotypes are what people think something is like with limited information. Unless one is presented with more information, they may never broaden or change an original idea or conception. They remain unfixed. Stereotypes can manifest in numerous different ways. Sometimes it is very obvious. In science, it can be as simple as hearing a parent say, “I was not good at science,” or “science is for boys.” At the early childhood age, it can be as simple as a child saying, “I want to dress as a mad scientist for Halloween.” Other times, it is more subtle, like the desire not to be like “the smart kids.”

Sometimes children act a particular way, to reinforce a stereotype or to get a particular reaction from a parent or not. Young children use a variety of experiences to test out their identities in science and “check” with the adults in their lives for

some sort of response, both positively and negatively. The teachers who unknowingly call on boys versus girls when asking science questions can reinforce a science stereotype. Parents' expectations, society's expectations, the media, and a teacher's response are all the beginning of children testing out others' ideas about their own science identity in early childhood. They will ultimately use these experiences to contribute to their identity in science in and outside the classroom and eventually a career. This suggests that what early childhood educators do is extremely important because they build the foundation for one's entire career.

The kinds of books teachers introduce and their assumptions must be explicitly challenged in early childhood classrooms. The kinds of television shows parents introduce must accompany some conversation about the scientists portrayed. Young children need to question and think through their ideas in order to broaden their idea about scientists. Children's interests in science are formed by age 14, and therefore the early childhood years are extremely important [3–5].

Science capital, as described by [6], is the academic, social, and cultural aspects of a student's life and how they may relate to a child's science aspirations. The role of family should not be overlooked in terms of influence on the child; [6] found that parental attitudes to science play an important role in shaping children's science aspirations. The survey data suggest that while a family's social structure location is important, family attitudes to science and their encouragement and fostering or not to science in their everyday life seemed to have an important influence [7].

Therefore, scientists and engineers are “who we are” and “what we do” or who we are and what we do not do. These stereotypes may form early on in life, and they may seem so acceptable because they come from our family of origin and we cannot recognize them. Young children need to be challenged in the classroom on their ideas for just these very reasons.

3. Science identity

Science identity, as defined by [8], demonstrates competent performance in relevant scientific practices with deep meaningful knowledge and understanding of science and recognizes oneself and gets recognized as a science person by others. The construction of this identity requires the participation of others as it is constructed socially within communities of practice [9]. Students develop identities through engaging with the practices and tasks of the science class upon entering a community of practice such as the science classroom [10]. Learning science in this community then becomes “a process of becoming to be, of forging identities in activity” ([10], p. 3).

Regrettably, in early childhood many students form perceptions of scientists and science that are narrow, inappropriate, and inaccurate [11–16]. Older elementary students included more indicators of stereotypical images in their illustrations than did 5- to 7-year-olds, suggesting that by fourth and fifth grades, students already have formed their limited views of who a scientist is [12]. Inaccurate views of scientists are widely held by students from elementary through high school [12]. In 6 years of research, having children draw pictures of scientists that are stereotypical, male images of white men in the laboratory increased with age [17]. Therefore, the least stereotypes are drawn by the youngest children [18]. In the examination of gender differences, only girls draw female scientists, and the majority of the female scientists are drawn by Kindergarten to second grade students, meaning children are less aware of the gender stereotypes associated with scientists at the youngest of ages [18]. Parents and teachers should provide experiences for young children that lead them toward rich and rewarding experiences in science [19].

4. What stereotypes mean: review of literature on children's perceptions of scientists

Starting at about second grade, one of the ways researchers have documented is that students possess stereotypical images of scientists by using paper and pencil/crayons methods [12, 15, 16]. This stereotype has been consistently portrayed by students for well 50 years [11–16]. This suggests that, as teachers and parents, there is a very short window of time in which to address this stereotype as it is forming. While paper and pencil may not be developmentally appropriate, another way may be through informally interviewing or talking to children regarding their ideas about who can be scientists and engineers.

Understanding this limited view individuals have of scientists is important because these ideas relate to children's science-associated educational and career aspirations. In other words, if children did not identify with such depictions, then they tend to not "see themselves" in these kinds of careers. A meta-analysis spanning five decades of Draw-A-Scientist studies studied that US children's gender-science stereotypes are more closely matched with males versus females. This is interesting considering women's representation in science has risen substantially in the United States, and mass media increasingly depict female scientists. Therefore, despite many efforts to attract females to science and make science a more diverse career field, children still associate science with mostly males.

Engineering is becoming increasingly popular in early childhood classrooms worldwide. Allowing students the opportunities to think and act like scientists goes hand and hand with the opportunities to play and build like engineers. For example, the *Next Generation Science Standards (NGSS)* has incorporated engineering throughout its K-12 standards. For example, one of the way to best describe how these two disciplines work together is to discuss one of the practices in the NGSS, Constructing Explanations (science) and Designing Solutions (engineering) [20]. Science is the way we make sense of the world or construct explanations, and engineering is the way we design solutions and/or solve problems and make the world better.

Therefore, research conducted on students' perceptions of engineers [21–23] has used similar drawing methods, like the Draw-A-Scientist Test, of the past decades. The activity is called the Draw-An-Engineer Test (DAET) or Draw-An-Engineer-At-Work (DAEWT), and the purpose is to have students describe their knowledge about engineers and engineering through drawing and sometimes written responses. These illustrations are then analyzed for stereotypical features described in the previous studies much like the illustrations of scientists of Draw-A-Scientist Tests.

Much in the same way, students have commonly associated beakers, chemicals, and lab coats with the tools scientists need to perform their duties. Students associate engineering with fixing, building, and working on things, and when asked to draw engineers, students portrayed engineers as physical laborers or working on cars [24–25]. Students often associated engineers with blueprints, computers, and safety gear and believed that engineers needed these items in order to perform their work. For these reasons, the parallel between scientists and engineers is a closely linked one.

5. Visiting scientists

It is not an uncommon idea for teachers to find ways for students to see scientists and engineers as individuals in a variety of settings and roles. Therefore, the most natural suggestion for broadening students' ideas or perceptions about scientist

might be to get them to meet a scientist or an engineer by bringing one into their classroom. While this sounds like a relatively easy task, there are several things to consider so that the teacher does not unknowingly reinforce the stereotype by recruiting a stereotypical scientist. The teacher should also be cautioned that there is tremendous value in meeting many scientists to appreciate the scope of many differences of scientists rather than limiting a scientist visit to one person.

Classroom teachers are limited by time. Not only do they struggle to meet day-to-day responsibilities of instruction, but also local, state, and national requirements, as well as other expectations, placed upon them. As a result, teachers need guidance in selecting appropriate scientists and engineers (visitors) for their students. However, it is not clear that matching mentors to students based on race or gender is necessary or more beneficial for early childhood classrooms. However, the number of studies that used visiting scientists with early childhood students has been small for a variety of reasons. These sorts of visits take time to set up, and the relationship between the scientist and even several scientists takes time to develop and establish. A well-educated scientist does not always make an appropriate person to discuss science topics in a developmentally appropriate way to early childhood students.

Visiting scientist programs are built on the assumption that a visiting scientist will benefit children's perceptions of who scientists are and the work they do. For students at this age, the best bet for the classroom teacher would be to ask for parent participation and engage parents in science and engineering careers in their classrooms. However, this can have drawbacks too, as the classroom changes year after year. Even if scientists and the engineer are carefully screened and properly trained for the classroom (and they would need to be for early childhood classrooms), there are simply not enough scientists to fill the need nationwide. Even when the resource pool is expanded to include such professionals as radio/TV meteorologists, county extension agents, and wildlife management professionals, the availability of scientists is still limited by their own work schedule and restrictions of geography. An oceanographer, for example, would be ready in one part of the country but not another. This would be something to consider.

Be sure to prepare your class with questions before the visiting scientists or engineer comes and after he/she leaves. This will get the students thinking about the kind of work the scientist does. Be sure to cue the students into things like how the scientist dresses, etc., to start addressing the stereotypes. Did he/she wear a lab coat? Did they work in a lab? Did they work from home? Once the visiting scientist/engineer leaves, be sure to process the visit with the students aloud and discuss their expectations versus what really happened, what surprised them, and how did they see this scientist/engineer as a "real" person?

Make no mistake; authentic experiences with successful scientists and engineers who can relate to early childhood students can be powerful. If there are opportunities to do so, teachers need to restructure their learning environment so that students' beliefs about science, scientists, and themselves lead to positive attitudes and to less-sex-role stereotypic views concerning the nature of science and the physical attributes of scientists. However, the time, opportunity, or desire is not available; the remainder of the chapter will discuss two other ways to combat stereotypes if no visiting scientists are available: trade books and television shows.

6. Combat the stereotypes: stereotypes in books

Because young children do not have the paper and pencil option available to them before second or third grade, a nonfiction historical trade book or television

show may be used to prompt explicit discussion. In this section, how to use trade books with early childhood students will be discussed.

6.1 Implementing nonfiction historical trade books

Linking nonfiction historical trade books and science content uniquely enables the teacher to model scientific thinking to stories of scientists and engineers in science lessons. This idea is that biographies of scientists can allow the teacher to highlight the human dimension of scientists and engineers while you encourage science learning. These stories will help broaden students' perceptions of scientists and engineers as real people and will add explicit and implicit opportunities for your students to consider science and engineering careers.

A book series that guides teachers in addressing non-stereotypical scientists [26, 27] has lessons linking the biographies of scientists and science content. This is one example of using nonfiction historical trade books in science teaching as a way to invite scientists and engineers into the classroom without the hassle of finding and scheduling guest speakers. Each chapter of this book presents three lessons based on children's literature biography of a scientist. Each lesson is organized according to NGSS [20] alignment, the character trait or disposition of the scientist, recommended science teaching strategies, and the learning cycle. However, if you decide to select the biographies for yourself, the following selection has guidelines for selecting biography-themed trade books for a science classroom.

6.2 Guidelines for selecting biography-themed trade books

The *Science Trade Book Evaluation Rubric* [28] can help teachers evaluate science trade books for use in their classroom. This rubric assesses the science- and literature-related appropriateness for trade books. It includes two main sections: literacy and science content. With respect to literacy, the rubric looks at plot development, imagination, and continuity if the story is fictional or whether the book contains sufficient information that is clearly organized in appropriate text structures if the story is nonfiction. The rubric further looks at the writing style, the suitability of the book's illustrations and graphics for the text it relates to, and the presentation of positive ethical and cultural values, including gender and racial representation. With respect to science content criteria, the rubric's key elements address the following: whether the science content is substantial, accurate, and current, whether the content has a "human face" (is personalized), and whether the content is intellectually and developmentally appropriate for the target audience. However, one aspect of science trade books not clearly addressed in the *Science Trade Book Evaluation Rubric* is the representation of scientists, particularly within the context of "science as a human endeavor."

Some places to begin looking for quality books include the National Science Teachers Association (Yearly Trade Book Awardees) and the Caldecott, Newbery, and Orbis Pictus Award lists.

6.3 Suggestions for selecting science trade books

When selecting science trade books with a focus on science as a human endeavor for their classroom science instruction, teachers may want to consider the following ideas below (in no particular order). The trade book should focus mostly on one particular scientist. The gender and/or ethnicity of the person(s) included within its pages may or may not be related. Meaning, the book is selected because of the work of the scientist, not necessarily the ethnicity or gender; however, there is nothing

wrong with selecting a book to explicitly teach that someone besides a white male can do science. Trade books, by their very nature, evoke a storytelling aspect of the book that undoubtedly reflects the human endeavor of science versus a presentation of sets of facts.

1. The trade book must contain accurate information. There are two things to consider: (1) the accuracy of the scientific information and (2) the attributes of the process(es) of science as delineated by the NGSS [20].
2. The trade book must include a nonstereotypical representation of a scientist. The trade book should include images of both men and women while remaining historically accurate.
3. The story presented in the trade book should illustrate the roles of people engaging in the scientific enterprise.
4. The illustrations in the trade book should be artwork that is esthetically pleasing in a way that encourages children to want to enjoy the book over and over again. Books with high-quality illustrations will help achieve this goal. These trade books stand out because they are so different from the typical informational texts currently found in the science sections of the bookstore. Informational texts are read for information, and we encourage students to read trade books for enjoyment.
5. The trade book must be age appropriate, and the practice of science must include students' practice and learning. The content of the trade book must be both age and developmentally appropriate for its intended audience so that readers can cognitively connect with what is being presented.

Gather the science trade books, and then consider the following:

Assess their science content for accuracy and developmental appropriateness, so the books clearly suit your students' reading ability ranges, interests, and abilities. Students should be able to grasp the scientific concepts that are being presented.

1. Assess the books' literacy qualities, including the narrative, style of writing, and cultural appropriateness.
2. Determine how well the books show the personal side of science for the main characters (i.e., determine how well the books describe science as being a human endeavor).
3. Consider the quality of the illustrations that help tell the story. For the age and developmental levels of your students, consider the brightness of the colors and whether the photographs or other types of illustrations are understandable and appropriate.

7. Combat the stereotypes: stereotypes in TV

Young children do not have the paper and pencil option available to them before second or third grade, a nonfiction historical trade book or television show may be used to prompt explicit discussion. In this section, how to use a television show with early childhood students will be discussed.

1. Select a television show that has a scientist included. The stereotypical or non-stereotypical portrayal of the scientist is not as important as the discussion that will follow between you and the young scientist.
2. Discuss with your child or your class some explicit assumptions about the scientist* on the show. For example, does the scientist wear a lab coat? Do they always work in a basement? What activities are they doing that considered science?
3. Just start asking the child questions about scientists, and see where it leads. Try to listen to the child and know that you do not have to answer every question.

*This can also work for field trips or visits like the zoo or science centers that have places where scientists are working on site.

7.1 Sid the Science Kid

Sid the Science Kid was selected as an example in the section because this author has used this television show for a research study to understand what aspects of science preschoolers were exposed to during the 1 and 30 minute episode. The goals of this particular study were (1) to analyze process skills: observing, inferring, classifying, measuring, predicting, and communicating within each episode; (2) to evaluate the number of questions asked within an episode; and (3) to evaluate and analyze how and who used the word “scientist” during each episode. Overall study findings (about the use of process skills) suggested preschoolers are exposed to observation and predicting most often while watching the television show and are exposed to an average of fifteen questions per 30-min episode. The explicit and implicit use of the word scientist (an average of five times per episode) might actually help young children visualize themselves as scientists [29].

Another research study about Sid the Science Kid found that the show successfully engaged both preschool children and their adult caregivers. It also reported that during and after viewing Sid the Science Kid, children asked more questions related to the concepts from the programs [29]. This is not surprising since children’s exposure to particular topics would naturally lead to the questioning of new information in which they were exposed. It was found that when comparing viewers and non-viewers when presented with similar materials to those they had watched on Sid the Science Kid, the children in the viewer’s category replicated the activities and use terminology they heard on the show, while nonviewers did not [30]. In a study with adult viewers, adults reported increased confidence with science content and increased comfort and interest in engaging in science activities with their preschool-aged children (29). Another reason this show would be good to have a discussion about the role of the scientist was that it was specifically found in a research study to measure the impact of the show on caregivers’ reports of low-income children’s science talk at home and found that watching the show had a positive impact on children’s science talk [31].

7.2 Who is Sid?

Sid is a “Science Kid” who wants to be a scientist when he grows up! The television show produced by the Public Broadcasting System first began in 2008; since then they have aired about 70 episodes about the 4-year-old Sid. The main character, Sid, is an inquisitive preschooler who is always asking questions about how things work and the world around him. As he goes to preschool each day, he tries

to answer these questions using the nature of science and basic science principles along with the help of his classmates (May, Gerald, and Gabriela).

The idea for the show was created around Sid and his question for each episode, and every show has basically the same blueprint. There is a brief description of the show as Sid begins each day with a question on his mind. As he greets his family for breakfast, he includes them in his science experiment. Then, he is off to school, and he brings the same question he is wondering about to the school playground usually in the form of a survey. His teacher, then, investigates whatever the particular question he has on his mind for that day at school. After school his grandmother reinforces what he has learned that day on the ride home from school.

The conceptual content of Sid is based in the *National Science Standards* [32], Cognitive Learning Theory, and on the preschool science curriculum, *Preschool Pathways to Science* [33]. The topics discussed on the show include earth, life, and physical science. Preschool specific topics per episode include tools and measurement, changes and transformation, senses, health, simple machines, backyard science, weather, the body, force and motion, environmental systems, light and shadow, technology and engineering, and living things.

8. Conclusion

It is recommended that teachers restructure their learning environment so that student beliefs about science, scientists, and themselves will lead to positive attitudes and to less-sex-role stereotypic views concerning the nature of science and features of a typical scientist [34]. This chapter has suggested that teachers can successfully address stereotypes in existing early childhood science classroom without restructuring their entire classrooms. Simple addition and/or modifications of trade books and/or television episodes (or visits from scientists) will serve their students well, by creating opportunities for discussions to broadening early childhood students' ideas about who can be scientists and engineers.

This chapter examined the development of the young scientists. It is often accepted that approaches to teaching young children in general include science and seeing themselves as scientists. However, as children progress through the school years, something happens with traditional schooling, and children often lose their curiosity and their sense of being scientists. They tend to try in fit in traditional idea of what others believe they should be a scientists or not, and this contributes to their science identity beginning as in early childhood.

In early childhood settings, children must be supported in their own role as scientist, and exploration is key to seeing themselves as a scientists. The Reggio Emilia approach and the Montessori method both were mentioned earlier in this chapter as examples of learning environments where children can "see themselves as scientists". Thus, children assume the role of scientists naturally.

Young children are impressionable and are forming images of not only their own identity but also their science identity. This is an important realization for teachers and parents of young children to recognize so that they can have fruitful discussions to uncover any stereotypes or limited thinking on the part of the young child. As previously discussed in this chapter, this can be accomplished through several ways that include trade books, trips to the zoo, or television shows. The most important aspect is that it is intentional on the part of the adult to try and build a communication stream between the child and the adult to discuss the implicit and explicit assumptions that will inevitably come with age and culture.

Early investment and exposure to scientists and engineers can inspire many years of discovery, even if children do not enter science careers. Finding

developmentally appropriate trade books and television shows to address stereotypes can be both meaningful and relevant to the everyday lives of young children and their teachers. In addition, science content is framed in relatable ways to its characters yet investigated through the nature of science, through posing questions and investigating objects and events that can be directly observed and explored for young scientists.

This chapter offered some practical tips for teachers because there is a real need for professional development for early childhood teachers on the issues of stereotypes in general.

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Author details

Donna Farland-Smith
The Ohio State University, Mansfield, OH, USA

*Address all correspondence to: farland-smith.1@osu.edu

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