

Review

Reimagining Science Learning in Early Childhood Through Storybook Reading

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Abstract

This paper presents a model for reimagining science learning during the early childhood years through storybook reading. Much of the research on storybooks in early childhood has emphasized how storybooks promote knowledge acquisition in literacy, social–emotional learning, and science. This model proposes that shared science storybook reading, through interactions with adults and society, integrates these domains and encourages the development of skills critical to success in science fields such as persistence in the face of failure and growth mindset. The model is situated within two theoretical frameworks: a social interactionist framework that adult–child interactions during a shared storybook reading can advance children’s learning and an ecological systems framework, which highlights how early development occurs in informal and formal learning environments in preschool through second grade, and within the context of larger societal values surrounding science.

Keywords: early childhood science; storybook reading; young children and science



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1. Introduction

In 2022, the Florida Department of Education reported that approximately 41% of mathematics textbooks (71% were for grade levels K–5) submitted to the state were rejected due to prohibited topics such as *social emotional learning in mathematics*, *inclusions of Common Core* and *references to critical race theory*. Defending Florida’s rejection of the mathematics textbooks, Governor Ron DeSantis argued that “math is about getting the right answer. And we want kids to learn to think so they can get the right answer. It is not how you feel about the problem” (*New York Times*). In the domain of science, the inclusion of science topics like the theory of evolution and climate change in science textbooks and curricula has been an area of controversy in the US for decades. Despite consensus among scientists about these topics, they remain politically controversial (Schwartz, 2023). In recent years there has been a spate of proposed state bills across the country that would force science teachers to present both sides of controversial science topics, even though one side has no scientific basis (Schwartz, 2023; Summers, 2024). Whether or not these bills become law, these attempts by states to enforce a rigid pedagogical approach around science and mathematics have implications for practices in all STEM (science, technology, engineering, and mathematics) fields, as these fields have historically been grouped together and viewed as requiring integrated skillsets (see Roehrig et al., 2021). In this paper, we focus on early science education while recognizing that STEM fields are interconnected and that the proposed framework may have implications across STEM fields. The goal of early science learning is not solely about getting the right answer, but about developing 21st century

skills such as critical thinking, creativity, and problem-solving that will prepare students to enter an increasingly complex workforce (National Research Council, 2013). In a world of misinformation, such scientific and critical thinking skills are foundational skills to prepare children from a young age to be “critical consumers of knowledge” (e.g., evaluate evidence, determine reliable and trustworthy source of information, make data-driven decisions) in daily activities (National Academies of Sciences, Engineering, and Medicine et al., 2021).

The goal of this review paper is to present a model of children’s science learning via storybooks during the early childhood years that acknowledges success in science as not only an opportunity for knowledge acquisition, but also as a dynamic process that requires social–emotional learning skills, literacy, and adult–child interactions. This review paper aims to address three important ideas:

1. Young children can learn science through storybooks and conversations with adults during scientific storybook interactions, which facilitate engagement in science.
2. There is more to science learning than just content knowledge: children’s sense of belonging, understanding of science as a process (and the relation between failure, effort, and success in science) and motivation are important constructs when considering how to engage young children in science.
3. Science storybooks are one tool for engaging all children (including children from underrepresented groups in science fields) in science during the early childhood years by integrating core literacy, science, and social–emotional skills.

2. Integrating Theory and Practice of Shared Science Storybook Reading in Early Childhood

Our model draws on social interactionist and ecological systems frameworks as well as growing literature in psychology and education to examine how children’s science learning during the early childhood years occurs through scaffolded social interactions and conversations during shared storybook reading sessions with more knowledgeable others (Bronfenbrenner, 1977; Rogoff, 2003; Vygotsky, 1978). Arguably, the early childhood years are a critical time to foster children’s engagement, learning, and interest in science, setting the foundation for science education in formal schooling. From a young age, the language in conversations with adults (including teachers and caregivers) during scientific storybook reading interactions can enhance or diminish children’s science learning and the extent to which they feel a sense of belonging in science (e.g., Haber et al., 2024; Leech et al., 2020; McGuire et al., 2020; Miller-Goldwater et al., 2023, 2024; Rhodes et al., 2019; Shirefley et al., 2020; Shirefley & Leaper, 2022). We highlight a few key reasons for why our paper focuses on children’s science learning during the early childhood years.

First, from a young age, children are very curious individuals, and they can learn a great deal of knowledge about the world around them through direct exploration, experimentation and play (e.g., Jirout & Newcombe, 2015), museum and zoo visits (e.g., Callanan et al., 2020), and storybook reading (e.g., Ganea et al., 2011; Haber et al., 2024; Kelemen et al., 2014; Miller-Goldwater et al., 2024). However, in the science domain, children may rely on information from others to learn about more complex scientific processes such as electricity or how rainbows form (e.g., Haber et al., 2021; Haber et al., 2022b; Leech et al., 2020). Although adults many spontaneously provide information to young children, children often acquire knowledge from adults by asking questions (e.g., Butler et al., 2020; Chouinard, 2007). Indeed, children can acquire scientific information by directing questions (e.g., “why do leaves change color?”, “why are there clouds in the sky?”) to teachers and caregivers. Children’s early scientific conversations (adult–child question–response follow-up exchanges) can foster children’s science learning during the early childhood years (Butler et al., 2020; Haber et al., 2021; Haber et al., 2022a). However,

research indicates that by the time children enter K-12 schooling, there is a significant decline in the number of questions children ask, suggesting that the early childhood (primarily the preschool years), is a critical timepoint for fostering children's curiosity and question-asking behavior in the science domain.

Second, despite children's early interest in engaging in scientific activities during the early preschool years, by middle childhood, children's sense of belonging in science declines, which is especially true among girls as well as children from racial and ethnic minoritized or lower-socioeconomic status backgrounds (groups that are underrepresented in STEM fields, e.g., [Lei et al., 2019](#)). Further, research indicates significant disparities in children's motivation to participate in science activities, which only grows with age in K-12 schooling and higher education (e.g., [Bian et al., 2017](#); [Curran & Kellogg, 2016](#); [Curran & Kitchin, 2019](#); [Niu, 2017](#); [Rhodes et al., 2020](#)). Thus, the early childhood years are a critical time for understanding children's science learning. More specifically, we present a model of exploring science learning through storybooks that acknowledges success in science as more than knowledge acquisition, but as a dynamic process that requires social-emotional learning skills, literacy, and adult-child interactions.

2.1. Social Interactionist Framework

The social interactionist framework provides a critical framework for understanding how children acquire knowledge about the world (especially in the science domain) through social interactions with learning partners during the early childhood years. According to a social interactionist framework, children learn information not just from their own firsthand experience, but through interactions and conversations with more knowledgeable social others such as caregivers and teachers ([Vygotsky, 1978](#)). Through scaffolded interactions and conversations, adults can activate their prior knowledge and guide children's early learning within their "zone of proximal development" ([Callanan et al., 1995, 2020](#); [Crowley et al., 2001a, 2001b](#); [Legare et al., 2017](#); [Luce et al., 2013](#); [Rogoff, 2003](#); [Willard et al., 2019](#)). Drawing on this approach, learning is embedded in meaningful, guided interactions and activities including shared storybook reading with others ([Legare et al., 2017](#); [Rogoff, 2003](#); [Siegel et al., 2007](#); [Tenenbaum & Callanan, 2008](#)).

We argue that storybooks can be one effective tool for scaffolding children's science learning by providing caregivers and teachers with developmentally appropriate and scientifically accurate information that children may not encounter in everyday conversations in home or classroom settings ([Leech et al., 2020](#); [Miller-Goldwater et al., 2023, 2024](#); [Shirefley et al., 2020](#); [Shirefley & Leaper, 2022](#)). To date, storybooks have traditionally been studied in relation to children's literacy and mathematical learning. An extensive body of research indicates that reading storybooks with adults (e.g., caregivers, teachers) is associated with gains in children's vocabulary development, emergent literacy and reading comprehension skills, understanding of numerical concepts, and more generally speaking, children's school readiness skills (e.g., [Anderson et al., 2005](#); [Brown et al., 2020](#); [DeBaryshe, 1995](#); [Demir-Lira et al., 2019](#); [Duncan et al., 2007](#); [Farrant & Zubrick, 2013](#); [Flack et al., 2018](#); [Fletcher & Reese, 2005](#); [Frijters et al., 2000](#); [Hendrix et al., 2019](#); [Horst & Houston-Price, 2015](#); [Leech et al., 2022](#); [McNally et al., 2023](#); [Mol et al., 2008](#); [Raikes et al., 2006](#); [Scarborough & Dobrich, 1994](#); [Sénéchal et al., 1996](#); [Shahaeian et al., 2018](#); [Uscianowski et al., 2020](#); [Van den Heuvel-Panhuizen et al., 2009, 2016](#); [Wasik et al., 2016](#)).

In the science domain, conversations and interactions during shared book reading sessions with adult learning partners create opportunities for children to ask questions (primarily "why" questions about the world) prompting adults to offer scientific explanations (e.g., providing information regarding causal mechanisms) about scientific phenomena or process that children cannot always learn through firsthand exploration, and in turn,

this exchange may enhance or diminish children's engagement in science during the early childhood years (Callanan et al., 2020; Callanan & Jipson, 2001; Crowley et al., 2001a, 2001b; Haber et al., 2021, 2022b; Haden, 2010; Haden et al., 2014; Leech et al., 2020; Leech, 2024; Tenenbaum et al., 2005; Willard et al., 2019). In early childhood, adults play a significant role in supporting children's early literacy through shared storybook reading. Shared storybook reading between adults and children can promote extratextual talk (language not in the storybook) about science through, for example, the use of dialogic reading prompts and talk focusing on scientific processes (e.g., questions, explanations), and can provide opportunities for promoting a sense of belonging and science learning and contribute to children's literacy and language skills (e.g., Fletcher & Reese, 2005; Haber et al., 2024; Haden et al., 2023; Leech et al., 2022; Miller-Goldwater et al., 2023, 2024; Purpura et al., 2017; Shirefley & Leaper, 2022; Shirefley et al., 2020; Zevenbergen & Whitehurst, 2003). In early childhood settings, adults read to children either in dyads, small groups, or a larger classroom setting is common. Often, children are not yet reading or are just learning how to read and therefore cannot access information directly from books on their own. Thus, early childhood caregivers have an opportunity not only to read the story text, but also to build on the content of the storybook via question-asking and explanation exchanges in order to engage children and promote dialogue, vocabulary, social-emotional learning, and science concepts (to list just a few of the relevant possibilities).

2.2. Ecological Systems Theory

Ecological systems theory (EST) provides another useful framework for understanding how science storybooks impact young children's science learning and motivation. EST considers how a child's development is influenced by the complex, dynamic interplay of their environment with the people and places around them (Bronfenbrenner, 1977). Bronfenbrenner (1977) defines four primary systems in a child's environment that impact their development: the microsystem (individual, family, and school-level interactions), the mesosystem (the relations between microsystems such as a parent attending their child's school open house), the exosystem (indirect systems that may impact a child such as a parent being laid off), and the macrosystem (broader socio-cultural values such as individualism or patriarchy). Of these four systems, the most relevant to our proposed model are the microsystems and the macrosystems. At the level of the microsystems, storybook reading provides opportunities for interactions between parents, teachers, and children surrounding storybook content. Prior work has used EST to examine how shared book readings in the home learning environment relate to language development (Grolog, 2020). These interactions are not limited to the words in the storybook, but can be built upon through relevant question-response exchanges between adults and children. At the level of the macrosystem, the production of science storybooks is impacted by prevailing socio-cultural beliefs and values about who belongs in science and what skills are required to succeed in science subjects in school and in the science workforce (e.g., Michell et al., 2018). For example, some research has shown that children's perceptions of science are broadened after reading science storybooks featuring diverse characters, but other work has reported that science picture books continue to feature primarily White, male characters (Finson et al., 2018; Sharkawy, 2009; Sharkawy, 2012). These societal values can also trickle down to the microsystems, impacting the ways in which adults and children talk about science during a shared storybook reading (consider Grolog, 2020). Because science storybooks disproportionately feature White, male protagonists, the selection of diverse and inclusive science storybooks is one way to guide adult-child conversation toward a broader understanding of what it means to be a scientist. Even if the storybook features a White, male protagonist, adults can help guide the conversation by asking questions and prompt-

ing discussion that promote all children's science interest and engagement (see the next section for specific details on inclusive conversational practices).

In expanding on EST, Bronfenbrenner (1986, 1994) added the chronosystem to his model of an individual's development. The chronosystem refers to an individual's development across the lifespan as well as to the changes in the environment over historical time. In our model, we especially consider the latter aspect of the chronosystem. In particular, we consider the ways in which societal values and beliefs about gender and race have changed across decades and centuries, impacting the ways in which adults talk about what it means to be a scientist.

The proposed model integrates social interactionist and ecological systems theories, recognizing the importance of adult-child interactions to development and acknowledging that these one-to-one interactions occur within the larger context of a given society. By integrating the two frameworks (rather than relying on a single theoretical lens), we can explore children's learning at multiple levels: within larger contexts and at the level of one-to-one interactions. Storybook reading is a particularly interesting interaction to explore within this integrated framework because (a) the words and images in storybooks can reproduce societal values of a given time and (b) adults have an opportunity to add to the storybook's message, by asking questions, making comments, and drawing children's attention to aspects of the story that they find most useful.

Importantly, we are not arguing that shared storybook reading experience are the best or only way to further enhance children's engagement in science during the early childhood years. We acknowledge that there are situations where shared storybook reading may be less accessible for families, particularly for families with limited literacy practice, lower literacy levels or for whom shared reading does not adhere to cultural norms or family values. For example, some research on Black families has demonstrated how oral storytelling traditions focusing on narrative scaffolding contribute to children's early scientific thinking skills by making personal connections to scientific concepts and processes in the natural world (e.g., Bang et al., 2014; Gardner-Neblett, 2024; Gardner-Neblett & Alvarez, 2024). We acknowledge that are other ways to engage children during the early years in science learning (see Wan et al., 2021 for review) including a focus on programming robots (e.g., Kazakoff et al., 2013; Sullivan & Bers, 2016, 2018), engineering design (e.g., Malone et al., 2018; Tank et al., 2018), and digital games (e.g., Schroeder & Kirkorian, 2016). However, a primary goal of storybooks in early childhood education is to convey content knowledge to young children. We argue that scientific storybooks are one (underutilized) way to build on practices that families may be engaging in to broaden our understanding of science learning in early childhood. Researchers have explored the use of storybooks in early childhood learning across many domains, including mathematics, literacy, social-emotional learning, moral reasoning, and science (e.g., Dore et al., 2017; Ganea et al., 2011; Purpura et al., 2023; Spencer et al., 2012; Strouse et al., 2018; Tare et al., 2011). Further, findings from other work highlight how families from diverse backgrounds engaging in book reading with young children at home (e.g., Bus et al., 1995; Haden et al., 2023; Nieto et al., 2019; Shirefley et al., 2020). Thus, it is clear that researchers recognize the value of storybooks as dynamic, accessible, and developmentally appropriate tools in fostering children's science learning during the early childhood years.

3. Scientific Storybooks as a Collaborative Tool for Enhancing Science Engagement and Learning During the Early Childhood Years

The proposed model (see Figure 1) illustrates the mechanisms through which science storybooks integrate core literacy, scientific, and social-emotional skills to foster children's engagement and learning in science. Our model aligns with and builds upon recent discus-

sions about how children ‘learn through language’ (Rowe & Snow, 2020); social interactions provide children with more than just language learning opportunities. Whereas children in elementary school classrooms in 2019 spent over 90 min on English Language Arts and nearly 60 min on math, fewer than 20 min per day were spent on science (National Academies of Sciences, Engineering, and Medicine et al., 2021). We argue that such scaffolded, shared scientific storybook interactions create learning opportunities that integrate core literacy, scientific and social–emotional skills. Because storybooks are accessible and often cost-effective, they provide one way of engaging all children, including children from underrepresented groups in science.

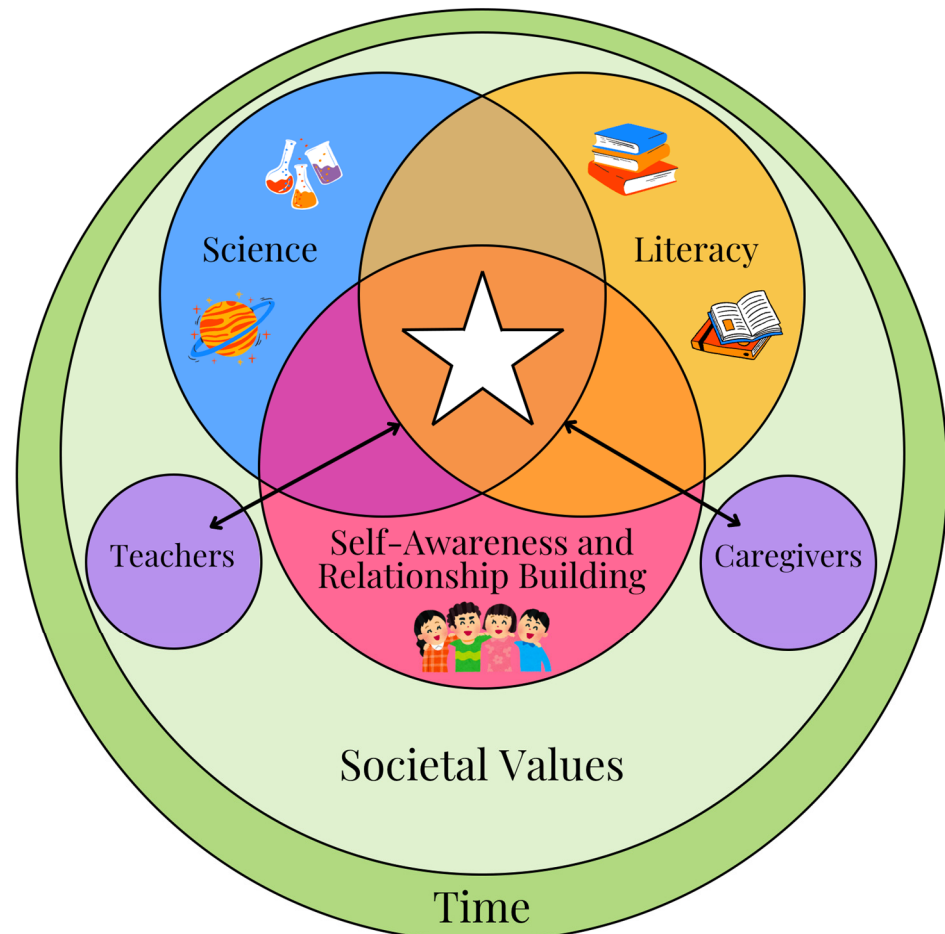


Figure 1. Model illustrating how shared science storybook reading impacts children’s early science learning and is impacted by adult–child interactions and societal values over time.

First, as noted above, storybooks foster children’s early oral literacy and language skills and introduce them to new vocabulary not found in everyday conversations in home or school environments (e.g., Mol et al., 2008; Wasik et al., 2016). In the domain of mathematics, research has shown that the incorporation of mathematical language, quantitative and spatial words that represent key mathematical concepts (e.g., several, fewer, above, between) in storybooks (Purpura & Reid, 2016; Purpura et al., 2017) fosters children’s math learning. In the domain of science, storybooks can be particularly useful as many science concepts cannot be learned through first-hand experience alone. For example, researchers have explored storybooks as a method for helping young children learn complex science topics such as balance, evolution, natural selection, and electricity (e.g., Aydin et al., 2021; Brown et al., 2020; Emmons et al., 2018; Ganea et al., 2011; Kelemen et al., 2014; Leech et al., 2020; Purpura et al., 2017, 2023). Indeed, Strouse et al. (2018) provide

a comprehensive review of which features of storybooks have been shown to impact young children's learning in the domains of biology, physics, and general problem solving. Through interactions during storybook reading sessions, adults, including caregivers and teachers, can encourage children to make personal connections to the story as well as activate their prior knowledge about a topic (Haber et al., 2024).

Second, science learning in K-12 schooling is grounded in eight core practices, including asking questions, engaging in argument from evidence, and constructing explanations (National Research Council, 2013). As important as it is to convey science *content* knowledge to young children, it is also critical to engage young children in the *process* of science and provide them with the tools they need to persist through that process (e.g., asking questions, constructing explanations from evidence, developing multiple solutions to solve problems). Caregiver-child interactions during shared scientific storybook reading create opportunities to foster both children's understanding of scientific content as well as foster their understanding of the relation between effort, failure, and success in the science domain (e.g., Haber et al., 2024; Leech et al., 2020; Shirefley et al., 2020; Miller-Goldwater et al., 2023, 2024). Although science fields are stereotyped as requiring innate intelligence to succeed, the methods of science involve failure as a rule (Chestnut et al., 2018; Leslie et al., 2015). In order to succeed, one must have the motivation to persist in the face of initial setbacks and failure (Chestnut et al., 2018). Attribution theory provides a helpful framework for understanding how failure in science could lead either to persistence or to quitting (Graham, 2020; Kumar et al., 2023). When a child fails in theory, their attribution of why they failed impacts their near and potentially distant future decision-making. Determining these attributions are complex and comprises many factors. As an example, if they attribute the failure to a lack of innate intelligence (i.e., something they cannot change and that they see as critical to success), then they may decide not to persist, whereas if they attribute the failure to a lack of hard work or to being unlucky (both of which are malleable), they may decide to persist. Additionally, attribution theory acknowledges the role of affect in certain outcomes (Graham, 2020). If the outcome is a failed experiment, a child may feel frustrated, angry, sad, or other negative emotions, coloring their attributions of the failure. Adults can assist in two ways. First, by reframing what a failed experiment represents in the context of science such that the "failure" is seen as a part of the process and even a part of the process that can be fun, exciting, and something that sparks curiosity. And second, by helping children learn how to acknowledge negative feelings and then work through feelings of frustration constructively. Recent work has begun to explore science storybooks as a way to boost young children's persistence and science interest (e.g., Haber et al., 2022a, 2024). Such practices highlight the importance of *process* (i.e., skills necessary to effectively participate in science) in addition to *content* in science learning.

Third, social-emotional learning (SEL) can be defined as "the process through which all young people and adults acquire and apply the knowledge, skills, and attitudes to develop healthy identities, manage emotions and achieve personal and collective goals, feel and show empathy for others, establish and maintain supportive relationships and make responsible and caring decisions" (Collaborative for Academic, Social and Emotional Learning, 2020). SEL has been linked to high academic achievement from preschool to adolescence (e.g., Durlak et al., 2022). SEL is a broad topic and involves many intersecting competencies and constructs. The Collaborative for Academic, Social, and Emotional Learning (CASEL) framework provides five core competencies for building SEL: self-awareness, self-management, responsible decision-making, relationship skills, and social awareness (Collaborative for Academic, Social and Emotional Learning, 2020). For the sake of clarity and concision, in this paper, we are targeting two of these competencies: self-awareness and relationship skills. Self-awareness encompasses a child's emotional understanding and

ability to identify their emotions and connect those emotions to their beliefs ([Collaborative for Academic, Social and Emotional Learning, 2020](#)). Relationship skills include the ability to collaborate, communicate, and problem solve in group settings ([Collaborative for Academic, Social and Emotional Learning, 2020](#)). The ability to understand one's emotions in developmentally appropriate ways and to build positive relationships with peers and adults is critical to children's success in the world. It is also critical to children's success in the domain of science because in order to be successful in science, children must be able to navigate the complex emotions that can emerge from failing at a science task and must be able to engage in constructive problem solving and collaboration with peers and adults on scientific topics.

The center of our model (represented by a star in Figure 1) illustrates what we argue to be the impact of shared storybook reading on children's early motivation and learning in science. Children's early engagement in science is often influenced by their approaches to learning. The goal of this paper is not to present an exhaustive list of approaches to learning, but to highlight a few approaches that we argue are the foundation of science learning and engagement during the early childhood years. In particular, we focus on several approaches to learning at the center of the model, including children's beliefs about success and failure, achievement motivation, persistence, and sense of belonging in science.

3.1. Beliefs About Success and Failure Impact Motivation and Persistence

How do children respond to setbacks and failure during science activities? How might their beliefs about failure and success in science impact their motivation to pursue or interest in science activities? Imagine a child who is attempting to balance a scale (exploring about scientific concepts such as weight, cause and effect, balance, simple machines), it might take them multiple attempts to correctly place objects of varying weights on the scale before it is straight. Importantly, if a child becomes frustrated that the scale is not straight after trying the first objects, the child might decide that they are no longer interested in the activity. Children's achievement motivation, which is conceptualized here as a "constellation of beliefs and behavior" impacting multiple facets of children's early learning including their performance, the extent to which they decide to engage in challenging tasks, and their beliefs about success and failure ([Bempechat & Mirny, 2005](#)).

In the domain of science, there is a pervasive view that success requires innate brilliance to succeed and this stereotype influences children's decision-making and beliefs about themselves and others (e.g., [Chestnut et al., 2018](#); [Master et al., 2016](#)). It also impacts their motivation to engage in activities where innate brilliance is seen as the key to success. For example, prior work has found that six-year-olds girls are more likely to choose to play a game designed for children who "work very hard" (emphasizing effort) over a game designed for children who are "very smart" (emphasizing brilliance; [Bian et al., 2017](#)). Related work demonstrates that when 4- and 5-year-old children hear a story about a famous scientist who achieved success through effort (rather than brilliance), they were more likely to persist longer on a challenging task ([Haber et al., 2022a, 2024](#)). Thus, science storybooks integrating science topics with social-emotional learning can impact children's approaches to learning and their early motivation to engage in science activities.

Motivation is also influenced by an individual's beliefs about and attributions for success, failure, and intelligence ([Dweck, 2008](#); [Graham, 2020](#)). For example, imagine Sage, a child in a second-grade classroom who, as part of a science lesson, has been asked to develop a vehicle that will move from one point to another as fast as possible using everyday materials that her teacher has provided to her. Her teacher has remarked that all of the students are being scientists. Sage has attempted to create three vehicles so far, but all of them have fallen apart or stopped before the finish line. Returning to attribution theory as a

framework, Sage's response to this failure is related to her attribution for why she failed. On one hand, Sage may develop a belief that she is bad at science. She may very well attribute her failure to lack of ability, an attribution that tends to be viewed by children as internal, stable, and uncontrollable, which in turn is likely to foster a fixed view of her science ability (Dweck, 2008; Weiner et al., 1987; Weiner, 2010). Alternatively, she may attribute her failure to lack of effort, which tends to be interpreted as something that is internal, unstable, and controllable, which would likely foster a view of her science ability as malleable fostering more of a growth mindset (Dweck, 2008; Weiner, 2010). These early attributions for success and failure can lay a foundation for future self-perception of science, ability, decision making, and academic success (e.g., Graham, 2020; Tang et al., 2024). Indeed, some work on mindset has shown that middle school and college students with a growth mindset, who viewed intelligence as a malleable trait, scored higher in science classes than students with a fixed mindset, who viewed intelligence as immutable (Blackwell et al., 2007; Grant & Dweck, 2003; Schmidt & Shumow, 2020).

Recent work suggests that mindset in science is malleable in early childhood, making early childhood a key time to intervene (Haber et al., 2024; Law et al., 2021). For example, Law et al. (2021) presented 5- to 12-year-old children with a one-shot growth mindset intervention at a science museum. Children who received the growth mindset intervention heard a brief paragraph connecting the exhibit to growth mindset, including stating that if children want "to strengthen your brain and be smarter," they can (Law et al., 2021, p. 4). Children in the growth mindset condition had lower stereotype awareness (i.e., more equitable beliefs about men and women in STEM) than children in the control condition (Law et al., 2021). This finding was especially meaningful for participants in early childhood (ages 5- to 8-years) because they started off with a higher stereotype awareness than older participants (Law et al., 2021). Returning to the example of Sage, if she attributes her early failure in science to a lack of innate mathematics aptitude, she might begin to view herself as "not a science person." This view may lead to a cycle of feeling excluded from science spaces, which could be further exacerbated by the fact that Sage is a girl, and as such, subject to societal stereotypes around science success as the province of males only, an issue we take up below.

3.2. Sense of Belonging and Group Membership

It has been clearly established that women and people of color are underrepresented in some science fields, including chemistry, mathematics, physics, and engineering (National Science Foundation & National Center for Science and Engineering Statistics, 2023). Part of this gender gap may be due to the fact that some of these fields are stereotyped as the province of masculine, nerdy, innately brilliant geniuses (Cheryan et al., 2017). As developmentalists, we recognize that these gaps do not merely appear from thin air, but emerge beginning in early childhood (e.g., Cvencek et al., 2011; Levine & Pantoja, 2021; Master, 2021). In the domain of math, for example, gender differences in mathematics attitudes and achievement are well documented (see Levine & Pantoja, 2021 for a review). In the domain of science, work on ameliorating gender differences in science is growing.

What factors/mechanisms might impact children's perceptions of scientists and sense of belonging in science? One mechanism that may impact children's sense of belonging in science is the language to which children are exposed during the early childhood years. In considering EST, the language that adults use when talking about science is impacted by current cultural norms and ideologies. Indeed, even the language that researchers use to study children's perceptions of scientists has changed over time. One way that researchers study children's perceptions of scientists is by asking them to explicate their image of a scientist, either via drawings, verbal or written descriptions, or a combination of these

methods (e.g., [Chambers, 1983](#); [Miller et al., 2018](#)). In an early study on students' images of scientists, [Mead and Metraux \(1957\)](#) asked students about their perceptions of scientists using language that reflected the patriarchal, heteronormative, and rigid gender roles of the time. For example, one item said,

“If you are a boy, complete the following statement in your own words. If I were going to be a scientist, I should like to be the kind of scientist who [blank] If you are a girl, you may complete either the sentence above or this one. If I were going to marry a scientist, I should like to marry the kind of scientist who [blank].”

The formulation of this item reflects the social and cultural norms of the period, reflecting that it was unlikely that a woman would be a scientist and more likely that a woman would marry a scientist (and so unlikely as not to be mentioned that a man would marry a scientist). These questions are entirely hypothetical, illustrating how deeply embedded these gender roles were in the minds of the researchers and participants in the study. The irony that Mead and Metraux were themselves female scientists demonstrates the social mores of the time. It is possible that including the caveat that a female participant could complete either sentence was an inclusive step for the time period. Regardless, this example demonstrates how the time in which we live impacts our cultural and social norms, filtering down into how we communicate with others, including with children.

As societal values shift and change, so does the way that we talk. For example, today it would be virtually unheard of for researchers to ask girls to imagine being the wife of a scientist on a Draw-A-Scientist task. Research can also shed light on what types of language encourage children's engagement and interest in science. A growing body of work has examined the use of action-based versus identity-based language on children's persistence in science. For example, prior research indicates that girls (aged 5–7) demonstrate greater interest in science and persist longer on a scientific task when an adults describes the activity in terms of activity-based (“we are going to do science”) rather than identity-based language (“we are going to be scientists”). [Rhodes et al. \(2019\)](#) argue that young girls may not identify as being part of the “scientist” group and this identity-based language may diminish motivation in science during the later years. Emphasizing actions and the process of science is important and can be especially useful in early childhood prior to the onset of formal schooling, when there is less focus on science as a labeled course to take but more focus on the science that exists in the everyday world. However, it is also important for children to view “scientist” as a viable future career path.

One way to provide children with opportunities to see themselves as scientists is to introduce children to scientific role models (e.g., [Master et al., 2016](#); [Master, 2021](#); [Gladstone & Cimpian, 2021](#)). Recent research emphasizes that in science, role models who are competent, whose success is attainable, and who come from underrepresented groups can be particularly effective in promoting engagement and feelings of self-efficacy in science (e.g., [Gladstone & Cimpian, 2021](#); [Master et al., 2016](#); [Shachnai et al., 2022](#)). Relatedly, it is important to move toward emphasizing science fields as collaborative and community-relevant domains, as this contextualization of science in relevant contexts can encourage students' interest and participation (e.g., [Elliott, 2015](#)). Little of the work on children's perceptions of role models has focused on early childhood, so this is an area ripe for future study ([Gladstone & Cimpian, 2021](#); [Kumar et al., 2023](#); [Shachnai et al., 2022](#)). In early childhood, science storybooks present an easy and accessible way for researchers as well as parents and teachers to introduce scientists to children. When selecting these science storybooks, adults should consider how effective the role model is (i.e., Are they portrayed as competent? Is their success attainable or not?; [Gladstone & Cimpian, 2021](#)). It is worth noting that even if the storybooks do not follow guidelines for effective science role models

to a tee, adults can use storybook reading time as an opportunity to add inclusive and effective language to the dialogue surrounding the topic.

We argue that one way to introduce young children to science in a way that emphasizes inclusivity and encourages participation of children from underrepresented groups is through storybook reading. Science storybooks featuring scientists from diverse backgrounds have been shown to broaden young children's perceptions of who can be a scientist (Sharkawy, 2012). These storybooks can also provide evidence when children are determining how to attribute failure in the domain of science. Diverse science storybooks can help adults and children move away from a narrative where only the few, homogeneous individuals with innate intelligence succeed in science toward a narrative where success in science is dependent on malleable traits like hard work. However, given that science storybooks recommended to educators have been found to feature primarily White and male characters (Finson et al., 2018), there remains a pressing need for storybooks that portray a diverse and representative picture of science and scientists.

3.3. Intersection of Literacy, Science, and Social–Emotional Learning in Storybooks

Arguably, motivation, mindset beliefs about success and failure and sense of belonging (approaches to learning) are a critical part of literacy, science, and social–emotional learning. Our proposed model highlights the intersection of these domains, an issue that has been little studied. In our model, we argue that storybooks are one way to connect and integrate learning in these three domains:

1. **Storybook reading can encourage children to make connections between their personal life experiences and the content of the story.** For early readers, teachers and caregivers can draw on their knowledge of individual children's lived experiences to help children relate to the characters or main themes in the story. In the domain of science, encouraging children's feelings of relatedness may be particularly important for fostering an early sense of belonging. For example, prior research has found that storybooks about famous scientists that emphasize that their success was due to their hard work and effort rather than their innate intelligence elicited caregiver-child conversation connecting children's experiences to those of the protagonist's and emotion language such as how the scientist feels when their experiment fails (e.g., "the scientist feels sad because her experiment did not work"; see Haber et al., 2024).
2. **Scientific storybook reading can also integrate literacy and science learning by introducing children to more complex, technical vocabulary targeting scientific phenomena that is not found in everyday conversation at home or school (National Research Council, 2013).** At the intersection of early literacy and early science learning, shared science storybook reading with adults can encourage children to make predictions about what will happen next and encourage children to communicate ideas about the story with others. For example, children can talk with teachers and caregivers about the steps in a science investigation, cause, and effect relationships, and using evidence to support arguments (see National Research Council, 2013 for a list of coordinated science standards, English Language Arts, and math state standards). Such conversations during storybook interactions can also create opportunities for children to develop skills around communicating effectively with others, skills which are a critical part of their socio-emotional learning (Collaborative for Academic, Social and Emotional Learning, 2020).
3. **Storybook reading is an inclusive practice that can encourage a sense of belonging in the classroom, within a family, and across domains of learning.** We argue that the methods of science require SEL skills, and that these are optimally fostered during the preschool years. For example, failure, which is inherent to the methods of

science, can elicit an understandable emotional response such as anger, frustration, or sadness. Responding to these emotions in a healthy way that promotes early learning and resilience requires critical socio-emotional learning skills such as labeling and identifying emotions, as well as adopting a growth mindset ([Collaborative for Academic, Social and Emotional Learning, 2020](#)). These early socio-emotional skills are aligned with critical constructs of early science and English Language Arts including “engagement, motivation, persistence and self-identity” ([Collaborative for Academic, Social and Emotional Learning, 2020](#)). Caregivers and teachers can leverage shared storybook reading to build children’s awareness and understanding of the emotions they may face during scientific exploration and provide them with a template for working through those emotions productively. Reading stories about characters that children can relate to and engaging in conversations that underscore the importance of learning from your mistakes and persisting in the face of challenges can help children realize that such experiences are normal, part and parcel of scientific and mathematical learning. In turn, when children face challenges in their own science and mathematics learning, they will understand that others like them have also experienced setbacks, have recovered from them, and that these experiences are part of the process of learning in science fields, creating a greater sense of belonging these domains.

4. Limitations of the Model and Future Directions

It is important to note that there are several limitations and future directions of our proposed model for how storybooks can be viewed as a collaborative tool for fostering knowledge, vocabulary and critical 21st century skills that would enhance science engagement and learning during the early childhood years.

First, it is important to acknowledge that although the price of storybooks can be low, using storybooks effectively in educational settings or at home often requires resources for (1) professional development workshops and training for teachers and (2) family engagement for caregivers at home. Although this would require funding, we argue, that such investment in understanding how children’s science learning occurs via storybooks (including an integration of emotional learning skills, literacy and science) would foster critical 21st century skills that are needed for children to be successful in the world today.

Second, as we highlight above, SEL is a broad topic that incorporates several constructs. Our model focuses on two of the five competencies described in the CASEL framework: self-awareness and relationship skills ([Collaborative for Academic, Social and Emotional Learning, 2020](#)), which we believe align best with the integration of SEL, literacy and science learning during the early childhood years. Importantly, there are other three other competencies for building SEL: self-management, responsible decision-making, social awareness ([Collaborative for Academic, Social and Emotional Learning, 2020](#)). Although addressing all five competencies for building for SEL is outside the scope of the current paper, we believe this could be an interesting direction for future research.

Third, although some research explores children’s early science learning, more empirical, longitudinal data is needed to understand how science interventions during the preschool and elementary school years impact engagement, persistence and interest in science in higher education and the workforce.

Fourth, an important future direction for researchers examining children’s early science learning and engagement is to consider integrating multiple frameworks. As we describe in the beginning of the paper, our model draws on social interactionist and ecological systems frameworks. To date, much of the research this field often focuses on one of three theoretical perspectives: constructivism, social interactionist theory, and ecological systems theory ([Kumar & Haber, 2025](#)). However, to consider how storybooks can integrate science,

literacy and SEL (learning outcomes across domains), we need more empirical data that draws on connections between such theoretical frameworks (Kumar & Haber, 2025).

Finally, to date, most of the research on science learning and engagement focuses K-12 schooling (often middle and high school students) and higher education. However, as we argue throughout the paper, the early childhood years, especially the preschool years, present an optimal time for developing interventions to foster children's early interest, persistence and engagement in science, before the beginning of formal schooling. Thus, an important next step for this work is to focus research on the early childhood years.

5. Conclusions

Research demonstrates that reading storybooks with adults is critical for fostering children's vocabulary development, reading comprehension skills, mathematical learning, and more generally speaking, children's school readiness skills. To this discussion, we have added how storybooks can also serve additional functions; they can encourage young children's engagement, motivation, persistence, and interest in science. In our model, we argue that children's science learning via storybooks acknowledges success in science as more than knowledge acquisition, but as a dynamic process that additionally requires social-emotional learning skills, literacy, and adult-child interactions. This model underscores the importance of viewing science learning as not only getting the right answer, but developing 21st century skills including critical thinking and problem-solving that will prepare students to be successful in the complex workforce today.

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