Science & Education (2025) 34:4275–4301
https://doi.org/10.1007/s11191-024-00606-z

ARTICLE

The Effectiveness of the Interactive Book Reading on Primary School Students' Images of Scientists

Bilge Islekler[1] · **Betul Ekiz-Kiran**[2] · **Erdal Senocak**[2]

Accepted: 2 December 2024 / Published online: 30 December 2024
© The Author(s), under exclusive licence to Springer Nature B.V. 2024

Abstract
The current study examines the effects of interactive book reading (IBR) intervention on second-grade primary school students' images of scientists. In line with this aim, the study primarily centered on the scientists' appearance, workplace, and gender. The IBR intervention was conducted through the teacher's read-aloud of a children's book about scientists and how they work and subsequent discussions with the students about the book. The Draw-A-Scientist-Test (DAST) was employed to determine the students' images of scientists before and after the intervention. Further, semi-structured interviews were performed with the students following each implementation of the DAST in order to enhance the comprehensibility of data (drawings) collected via DAST. As for the data analysis, the DAST-Checklist (DAST-C) was utilized to analyze the students' drawings. While the participants' drawings were encoded with DAST-C, the interview data of the same participants were used to clarify the unclear and uncertain items. The results revealed that the students had more stereotypical images of scientists before and moderately altered these images after the intervention. A transition from traditional to non-traditional was discovered regarding the students' images of the scientists' appearance and workplace. However, a minor difference was observed in the students' images of the scientists' gender, as a majority of the students portrayed the scientist as a man in the pre- and post-IBR intervention. By discussing the results of this research based on the relevant literature, some suggestions have been made for using children's literature in teaching scientists' characteristics to students.

1 Introduction

Research suggests that science education should start in the early years of schooling (Eshach & Fried, 2005). In this respect, at the initial stages of education, fostering an interest in science and an understanding of scientific concepts is crucial for building a strong foundation for lifelong learning. Children's literature offers a unique opportunity to introduce scientific concepts within the context of stories that are engaging and meaningful in the early years.

✉ Betul Ekiz-Kiran
betulekiz@gmail.com

[1] Mevlana Ortaokulu, Tokat, Turkey

[2] Department of Mathematics and Science Education, Tokat Gaziosmanpasa University, Tokat, Turkey

The trade books, with their rich narratives and captivating illustrations, make scientific subjects more relatable, enjoyable, and easier for young readers (Palincsar & Magnusson, 2001; Zeece, 1999). The narratives in these books can simplify complex ideas, provide real-world connections, and promote curiosity in a manner that traditional science texts may not (Morrow, 1996). Moreover, children's literature can address diverse learning styles, thereby ensuring engagement with students who might struggle with more conventional methods of science instruction (Fang, 2010). By immersing students in stories that incorporate scientific themes, educators can create a more holistic and integrated learning experience promoting both literacy and scientific understanding (Saul & Dieckman, 2005).

Children's books also serve as an effective tool to understand and broaden children's perceptions of scientists. Trade books with straightforward explanations about science and scientists can be used to illustrate how scientists carry out their research or to provide visuals of scientific activities that may not be easily accessible to children (Ford, 2006). Trade books are not only accessible and engaging for young readers but also provide opportunities for them to see scientists who look like them, who come from various backgrounds, and who engage in a variety of scientific work (Ford, 2005; Rawson & McCool, 2014). The stories in these books can play a crucial role in reshaping children's views by highlighting the human aspects of scientific inquiry and showing that science is a dynamic and inclusive field. Using trade books other than textbooks in science classes is an intriguing and convenient approach to teaching science concepts to primary school children (Banilower et al., 2013; Daisey, 1994). Teachers find science instruction for young children challenging for a variety of reasons. However, using children's books to teach science concepts is considered a viable solution because teachers are already familiar with this educational tool (Saçkes et al., 2009). Farland (2006) also revealed that the trade books about scientists broadened students' perceptions of scientists' appearance and activity.

While it is promising that children's literature is increasingly effective in teaching science content (scientific vocabulary, concepts, and discourse), concerns about which types of science trade books are best suited for science instruction are emerging. Incorporating trade books into young children's science education offers certain benefits but also presents challenges (Brunner & Abd-El-Khalik, 2020). Upon examining the trade books designed for elementary and middle school students, some researchers expressed concerns about how they frequently either neglect science content entirely or address it simplistically (Ford, 2006; Kelly, 2018; Schroeder et al., 2009). Kelly (2018) performed a content analysis of 28 books among Outstanding Science Trade Books designated by the National Association for Research in Science Teaching (NARST) in 2016. She revealed that the contents of the books do not represent scientific disciplines or the image of the scientist at the anticipated level, and the majority of scientist depictions in the books were male and white. She also pointed out that meticulously selected books can be beneficial in teaching children science content, such as how scientists work and who can become scientists. Brunner and Abd-El-Khalick (2020) also discussed how trade books can be a tremendous source for teaching science when meticulously selected and used. Similarly, Avşar Erumit and Akerson (2022) advocated that properly designed children's science trade books can effectively support science teaching.

This study aims to explore how a trade science book, which is a realistic fiction children's book featuring representations of explicit descriptions of science and scientists, shapes elementary school students' images of scientists. By examining students' responses to these narratives, educators and researchers can gain valuable insights into how young learners conceptualize science and its practitioners. Understanding these perceptions is essential for designing educational interventions that encourage children to view themselves as potential scientists, thereby promoting diversity and inclusion within the field of science.

2 Children's Images of Scientists

Comprehending how children perceive scientists and their work is critical in cultivating future generations' interest in science and their potential to pursue careers in scientific endeavors. Mead and Métraux carried out one of the first attempts in 1957. Subsequently, other researchers followed their lead to uncover or enhance children's perceptions of scientists. Chambers (1983) established the foundation for studies and conducted a study with children aged five to eleven to determine at what age they first develop distinct images of a scientist. He employed a tool known as the Draw a Scientist Test (DAST). Many researchers have utilized the instrument in the following years to reveal children's perceptions of scientists regarding appearance, gender, and workplace.

Since Chambers' study (1983), the perception of scientists, particularly through children's eyes, has been a topic of interest. Numerous studies have since explored how children from different countries view and depict scientists. For example, Newton and Newton (1998) studied the views of English and Welsh primary children on scientists using the DAST. According to the findings, children had a gender-biased stereotype and an unrealistic perception of the nature of scientists' work. They tended to portray the scientist as a middle-aged male, bearded and in a laboratory coat, and the scientists' workplace was still primarily indoors. Fung (2002) administered the DAST to Hong Kong Chinese primary and secondary school students to explore their images of scientists. He found that both groups of children from Eastern and Western cultures held similar stereotypic images of scientists. Children also demonstrated general trends, with an increasing number of stereotypical features appearing in their drawings as they grew older, as well as a dominant perception of scientists as male figures. In another study, Christidou et al. (2016) investigated American and Greek primary pupils' visual images of scientists with two instruments, DAST and a picture selection task. The results revealed that Greek and American pupils embraced certain elements of the stereotypical image of scientists and their work, consistent with Chambers' (1983) findings. In addition, the overall stereotypical images of participants did not differ based on their ethnic groups. More recently, Bozzato et al. (2021) examined Italian primary school students' images of scientists and their work, considering their gender and grade levels. The children primarily depicted scientists as male, solitary, and working indoors. Besides, these children were inclined to depict scientists aligned with their own biological sex, and younger children drew less stereotypical images of scientists compared to older ones. These studies, conducted over decades, have yielded consistent results over time. Stereotypes often illustrate scientists as male, wearing white lab coats, middle-aged or elderly, and working indoors (Barman, 1999; Ferreira & Valente, 2024; Finson, 2002; Losh, 2010). Researchers are concerned that these narrow views can limit children's understanding of the diversity and accessibility of scientific careers, potentially discouraging them from exploring science as a viable and exciting career path (Christidou et al., 2023; Miller et al., 2018a, 2018b).

While many studies have revealed that children hold stereotypical images of scientists, an increasing number of intervention studies have aimed to present realistic images of scientists and change students' stereotypical perceptions. Science camps, scientist-student interactions, book readings, and science fairs are some of the approaches used to broaden children's images of scientists and scientific work (Finson et al., 1995; Leblebicioglu et al., 2021; Sharkawy, 2012; Woods-Townsend et al., 2015). In these interventions, researchers aimed to help children develop a more inclusive understanding of science and scientists who are human elements of science. For instance, Farland-Smith (2009a) engaged middle

school students in laboratory and field exercises for a few days, providing them with direct interaction with five scientists. Findings unveiled that the majority of students developed a deeper appreciation for science. Furthermore, the student-scientist interaction not only enhanced students' interest in science but also enlarged their perspective on science as a human endeavor. On the other hand, Leblebicioglu et al. (2021) designed a one-week science camp with 12- and 13-year-old students to monitor the change in the image of scientists among students. Students worked with non-stereotypical scientists during the camps, both in formal settings where the scientists guided their inquiries into nature and informally during other interactions. Researchers discussed that the camps successfully reduced the stereotypical image of scientists as male and demonstrated that scientists could work in natural environments. As previously discussed, using children's books is an alternative to improving children's understanding of science and scientists. Research has demonstrated that reading children's books significantly enhances elementary students' motivation, comprehension of more complex scientific concepts, and achievement in science (Kletzien & Dreher, 2004). Books encompassing clear explanations about science and scientists can be employed to describe how scientists conduct their research or to provide visuals regarding scientific activities (Ford, 2006). Therefore, our study seeks to contribute to the existing literature by exploring how the interactive reading of a trade book, including explicit descriptions of science and scientists, shapes elementary school students' images of scientists.

3 Teacher-Student Interactive Book Readings

In their experimental study, Whitehurst et al. (1988) investigated the effect of parental picture book reading at home lasting one month on children's language skills. Research results displayed that children whose parents read books interactively improved their language skills and received significantly higher scores than children whose parents read conventionally. Additionally, the follow-up conducted nine months later revealed that the differences between both groups continued, although with a statistical decrease. Valdezmenchaca and Whitehurst (1992) also executed an experimental study, and a teacher performed book reading with 20 children from low-income status in a nursery using interactive reading techniques. The same teacher delivered individual arts and crafts instruction to children in the control group. Standardized language tests were used to evaluate the effects of the intervention, and measurements unveiled differences in favor of the intervention group. In their study with mothers and their children, Arnold et al. (1994) found that interactive reading strongly affects children's language skills. Similar studies conducted in the following years have shown that interactive book reading has significant effects on language development and learning efficiency in early childhood (Chang et al., 2023; Ergül et al., 2016; Neri et al., 2021; Toub et al., 2018; Williams & Mclean, 1997). Interactive book reading has also been used to increase children's learning efficiency in diverse areas besides language development, among which there are mathematics teaching (McGuire et al., 2021), teaching science concepts (Okyay & Kandir, 2021), parent–child interactions (Thomas et al., 2019), and socio-cognitive skills (Aram et al., 2013).

Interactive Book Reading (IBR) is a research-based and interactive approach to reading, particularly in the early years of preschool and primary education. The primary purpose of this approach is to engage children in reciprocal involvement with the book while it is being read to them, rather than passively listening to the text. Instead of reading a book from beginning to end, the reader (usually a parent or teacher) asks open-ended questions

about the book's content, encouraging children to think and respond. What is more, the reader also provides feedback to assist children in elaborating on their responses to questions or clarifying their thoughts. IBR is a flexible approach customized according to children's age and language development levels. In a number of previous studies, IBR interventions' impact on children's language and literacy skills was examined (Merga, 2017; Okyay & Kandir, 2021; Vanparys et al., 2023; Wasik & Bond, 2001). They disclosed that IBR has positive impacts on literacy skills and language development. In this respect, IBR is a valuable means for parents, teachers, and educators who desire to enhance reading and language skills in young children. Within the current study, the IBR approach was used in a read-aloud session of a trade book designed for young children explicitly referring to science and scientists.

4 Determining Children's Images of Scientists

Researchers frequently ask children to "draw a scientist" to understand better how they view scientists and scientific work. This raises the question of why children's drawings are commonly referenced. Since the late nineteenth century, researchers in the discipline of child art have considered children's drawings as essential windows into their mental processes and cognitive development (Quaglia et al., 2015). Thereafter, child art has received much attention as a subject for researchers across various disciplines. For instance, children's drawings were used to analyze expressions of personality traits, with interpretations primarily influenced by Freud. Duncum (1980) claimed that children might use drawing as a means of controlling or partially releasing powerful emotions. This idea emphasizes the role of drawing not just as a creative activity but as a therapeutic tool that helps children manage and express their emotions non-verbally. Lewis and Greene (1983) argued that many children might find answering questions uncomfortable or unenjoyable, but drawings offer a more appealing alternative. As to Farokhi and Hashemi (2011), using drawings in evaluations is a valuable approach, as most children typically experience enjoyment in drawing and engaging in this activity without any signs of stress or discomfort.

Children's drawings have been analyzed to gain insights into their perspectives on various aspects of their worlds. Such analysis laid the groundwork for renowned intelligence assessment tools, including Goodenough's (1926) "Draw-A-Man" test. The test was later reviewed and improved by Harris (1963). In 1957, Mead and Métraux, among the first researchers to describe a standard image of a scientist, asked students to discuss the science and life of scientists through a nationwide sample of essays. They revealed that students typically described scientists as tired-looking, middle-aged, or elderly white men, often unshaven, wearing white lab coats, and spending their time doing experiments in a lab. Twenty-five years later, Chambers (1983) developed a test called the Draw-a-Scientist Test (DAST) to reveal children's images of scientists. The test idea was proposed by Mead and Metraux (1957), but the procedures were outlined by Chambers (1983). It was not merely an extension of the Draw-a-Man test utilized to assess the drawer's intelligence, self-perception, or particular emotional states and conflicts (Chambers, 1983). Students' drawings were coded on seven types of indicators of the standard image of a scientist: lab coat, eyeglasses, facial growth of hair, symbols of research, symbols of knowledge, technology, relevant captions like formulae, taxonomic classification, and the "eureka" syndrome. Each drawing was analyzed, and a score ranging from one to seven was assigned to reflect the degree to which the standard image of a scientist was depicted. Later, Finson et al. (1995)

conducted reliability and validity tests for the DAST to improve the instrument's objectivity and interrater reliability. They developed a scoring checklist for assessing DAST drawings named Draw-A-Scientist-Test-Checklist (DAST-C), including a more detailed drawings analysis with eight indicators added to the seven original DAST lists. It identifies 15 stereotypical items to address further stereotypical images of scientists.

Despite other tools, the DAST has been widely used in several studies worldwide to explore the children's images of scientists. The advantage of DAST over other tools is that it does not require reading or writing and is straightforward to apply (Brochey-Taylor & Taylor, 2024; Farland-Smith, 2012; Hillman et al., 2014). It is primarily an effective instrument for overcoming the limitations of oral or written tests. In addition, it has been used with a wide range of groups, including kindergarteners and undergraduates (Hillman et al., 2014). Eventually, the DAST is a practical and frequently employed test for identifying the perceptions of scientists across various age groups and countries (Blagdanic et al., 2019; Emvalotis & Koutsianou, 2017). Therefore, the current study employed it as the primary data collection tool to reveal children's images of scientists.

5 The Current Study

This study aimed to determine second-grade primary school students' images of scientists and reveal the IBR intervention's effect on their images. The Draw-A-Scientist-Test (DAST) and interview forms were utilized to identify the students' images of scientists. Besides, a children's trade book titled "I Know: Scientists" by Senocak (2021) was used for the IBR intervention. This book emphasizes the images of scientists, who are the human element of science. Detailed information about the IBR intervention, the content of the selected book, and the image of a scientist presented in this book were provided in the methodology section.

As previously mentioned, children's books are regarded as an important resource to enrich primary students' images of scientists and scientific work. Brunner and Abd-El-Khalick (2020) emphasized that using trade books, which are marketed to the general public, offers an excellent approach to teaching science to young children. However, in children's books, the image of the individual engaged in science is frequently conveyed through the stories of well-known scientists (Leden et al., 2022). Allchin (2011) indicated that such stories reinforce the mythical status of science and may prevent children from considering a science career, as they may assume they will never attain this level of comprehension. Another issue about the perception of scientists is the convention of portraying scientists as mostly white Western men (Kelly, 2018; Rawson & McCool, 2014). As can be understood, most children's trade books contain many problematic, stereotypical images related to science and scientists (Leden et al., 2022). We hypothesize that IBR can enhance a deep conceptual understanding of students' perception of scientists, specifically when supported by meticulously selected children's trade books. In this study, we attempt to explore the effects of employing a well-designed children's trade book about the concept of a scientist through an IBR activity on children's images of scientists. Even though there are studies in the literature on the impact of traditional reading on children's images of scientists, no previous research has specifically investigated the effects of IBR intervention, in which children's books with explicit references to the role of scientists are used, on children's images of scientists. Therefore, the current study aims to fill this research gap in literature.

The main research question of this study was "How does the IBR intervention affect the second-grade primary school students' images of scientists?" The sub-research questions this study sought to answer were as follows:

1. How does the IBR intervention affect the second-grade primary school students' images of scientists' appearance?
2. How does the IBR intervention affect the second-grade primary school students' images of scientists' workplaces?
3. How does the IBR intervention affect the second-grade primary school students' images of scientists' gender?

6 Methodology

6.1 Participants of the Study

Twelve second-grade students enrolled in a primary school participated in this research, of whom two were female (S1 and S9) and the others were male. All of them were 8 years old. Pseudonyms were used to define students from S1 to S12.

6.2 Selection of the Participants

Pilot implementations were carried out with three separate groups: preschool students (6 years old), first-grade primary school students (7 years old), and second-grade primary school students (8 years old), who were the target audience of the trade book whose effects were investigated. However, during this process, the researcher observed that second-grade students exhibited more interest in the IBR activity, were willing to understand the scientific concepts in the book and interacted by asking and answering the reader's questions. Participants were asked to complete DAST before and after IBR for each pilot study. The data obtained from the second-grade students was observed to be more prosperous and more understandable than in the other groups. In addition, second-grade students frequently referred to scientific concepts in their answers to the open-ended questions posed in the DAST and utilized most of the scientific terms covered in the book that were used for the pilot implementation. Consequently, based on the observations about the pilot implementations, the decision was made to designate second-grade students as the research study group.

6.3 Context of the Study

The IBR intervention was executed with second-grade students at a private primary school. In this school's second-grade program, science is incorporated into the Life Sciences curriculum. The Life Sciences course comprised six units: Life at School, Life at Home, Healthy Life, Safe Life, Life in Our Country, and Life in Nature. Students engaged with the Life in Our Country unit during the two-week data collection period. A greater portion of the scientific material was addressed in the Life in Nature unit, which students had not yet studied. The participating students were not subjected to a curriculum different from that of their peers at school. Standard procedures persisted unchanged. They did not engage in a science fair, exhibition, or any other activity that would alter their images of scientists.

6.4 The Book Selected for the IBR Intervention

The book for the IBR is titled "I Know: Scientists" by Senocak (2021), written by a science education professor at the Science Education Department of a state university in Türkiye. It is a realistic fiction trade book since it has a fictional story built from reality and its laws. The outline of the book covered during IBR activity is provided in Table 1.

In the first column of Table 1, the main ideas covered in the book were presented. The supporting ideas of the main ideas were given in the second column. In the third column, three scientists' characteristics examined in the current study (i.e., gender, appearance, and workplace of a scientist) were associated with the ideas covered in the book.

The book's plot is as follows: Two primary school students hear the concept of a scientist on television and wonder about its meaning. They decide to get help from their teachers to satisfy their curiosity. Their teacher also takes them to visit a female scientist working on botany. Following the visit, these two friends get to know the scientist through the concepts in the book. The book's content includes the characteristics of a scientist (i.e., gender, appearance, and workplace of a scientist). The book refers to being curious, conducting experiments, keeping reports, discussing research results with other scientists, and many other concepts. The scientists depicted in the book are both male and female. In addition, they work both indoors and outdoors. The book also contains scientists from different research fields, such as botany, behavioral science, and archaeology.

In light of this information about the book selected for the IBR process, we believe that the current study is suitable for properly teaching the image of the scientist. The book explicitly addresses images of scientists and describes them accurately.

6.5 Details of the Intervention

This study aimed to identify second-grade students' images of scientists and the effect of the IBR intervention on their images. For this aim, the following IBR plan was developed (see Table 2).

The IBR was carried out for two weeks, with sessions occurring three days per week for two class hours (each 45 min) a day. It was applied in three stages: pre-reading, reading, and post-reading.

Considering the plan, the following steps were taken in the *pre-reading stage*. The words, pictures, and concepts in the story that should be emphasized were marked on the book written by the researcher, who was also the reader. The reader identified where to place emphasis and which examples to provide and decided which questions to pose during the reading stage (the marked words and sentences were presented in detail in the reading stage below). These questions and examples were arranged to encourage students' participation, and short reminder notes were appended to the researcher's book. After the preparations concerning the book, the essential physical arrangements in the classroom were made in the setting for reading, and environmental stimuli that would distract the students' attention were removed. For example, students were requested to clear their desks of other course-related equipment and were reminded to meet their water and toilet needs beforehand. Throughout the implementation period, physical arrangements were checked at the beginning of each lesson, and classroom order was restored when deemed necessary. After the physical arrangement of the environment, the book was distributed to the students. A preliminary examination was made by asking them to touch the book and turn its pages. Attention was drawn to the book's title and the front cover image, and open-ended

Table 1 Outline of the IBR book associated with scientists' characteristics

Central idea	Supporting idea	Scientists' characteristics covered
Who is a scientist?		Gender, appearance, workplace
Visiting the working environment of a young woman scientist working on plants		Gender, appearance, workplace
Chat with the woman scientist on scientists' characteristics	Curiosity Asking questions and searching for answers Research Observation Doing experiments Collecting and recording data Report on findings Share the research findings	Gender, workplace
Different research areas of scientists	Entomologist Oceanologist Astronomer Musicologist Archeologist Social scientist	Appearance, workplace
More about scientists	Imagination Problem-solving Collaboration Working under difficult conditions Frustration Invention	Workplace
Work as a scientist	*Initial Question:* Are you wondering what kind of animals live in your garden or on a nearby farm?	Workplace
Notes for parents	How could parents support children's images of science and scientists?	

Table 2 The IBR intervention plan

Steps	Implementation	Duration
Pre-DAST	Pre-DAST drawing session	45 min
Pre-reading (preparation)	Highlighting the words, pictures, concepts, etc., that will be emphasized, determining examples to be given and questions to be asked during IBR	45 min
	Arranging the physical environment in the classroom	
	Students' first encounter with the book	
Reading	Reading each page carefully	135 min
	Discussing pre-determined words, pictures, concepts, etc	
	Asking questions and eliciting students' responses about the story	
	Allowing all students to express their ideas	
	Providing feedback on students' responses and questions	
Post-reading	Engaging in a brief conversation with students regarding their impressions of the book's content	90 min
	Students' summary of the book in their own words	
	Asking students questions about the book	
Activity 1	Playing a game: Which scientist are you?	90 min
Activity 2	Meeting with a scientist	90 min
Post-DAST	Post-DAST drawing session	45 min

questions were asked to the students in this regard. Examples of these questions were as follows: "What is the book's title?" and "What does the picture on the front cover make you think?" Then, the reader showed the book and provided information about its formal features. Subsequently, the book's title was read, and information was given about its author, illustrator, and publishing house. For the back cover of the book, a student was requested to read the short text there, after which the researcher noted that this text could provide an overview of the book's subject. It was also expressed that such brief texts on the back covers of books generally offer insights into their subject matter. Consequently, the pre-reading implementation steps were completed, and the reading stage commenced.

In the *reading stage,* each page was attentively and interactively read alternately by students and the reader. The words (e.g., scientist, laboratory, experiment, behavioral scientist) and sentences (e.g., "One of the most important characteristics of scientists is that they are curious" or "Scientists sometimes do experiments."—The word *sometimes* in this sentence was emphasized to draw their attention to the fact that scientists do not always engage in experiments) to be emphasized on each page were marked in the reader's book before reading. Students were given guidance when necessary while stressing the premarked words and sentences, allowing them to express their opinions without straying from the topic. Students were sometimes asked to use the relevant words (e.g., findings) in a sentence and re-read the sentences the reader stressed. During the reading stage, efforts were made to ensure that all students participated in reading, with careful attention to giving equal opportunities to express their opinions regarding highlighted words or sentences. First, the pictures were examined on each page, followed by the text reading, and finally, the interaction was increased with open-ended questions. An example of a page from the book discussed with the students is provided in Fig. 1. On this page, students see a woman oceanographer working underwater with various living organisms.

For instance, the reader asked, "In this book, the scientist is a female. Could there be a male scientist?" or "What do you think about the workplace of scientists? Do they always

work in a laboratory?" Students were then provided feedback by correcting and elaborating on their responses to these questions at the end of each page. The reader aimed to help students form an accurate image of scientists through the feedback provided.

The steps in the *after-reading stage* were performed as follows: First, a brief conversation was held about whether the students enjoyed the book and the story's content. After that, they were asked to summarize the story. In addition, open-ended questions were asked about the content in order to reveal how their images of scientists changed and to enable them to gain insight into this matter. For example, the reader asked, "Why did the scientist in this story record his research findings?" or "If you were a scientist, what topic would you like to research?" and then gave feedback to the students by elaborating their answers.

Afterward, post-reading activities mentioned in the reading plan such as *Activity 1 and Activity 2,* were carried out. In Activity 1, the reader asked students, "Imagine you were a scientist. What is your research area? Describe your workplace and your features as a scientist." Among these two activities, Activity 2 highly attracted students' attention. Within the scope of it, a scientist working at the Vocational School of Health Services visited the students in their classrooms. This scientist was a young female behavioral scientist. The students asked her numerous questions about what kind of research she carried out, what subjects she was particularly interested in, whether being a scientist was challenging, and what steps they should follow to become scientists. Upon this visit, the IBR intervention was concluded.

6.6 Data Collection Tools

Data was collected through Chamber's (1983) Draw-a-Scientist Test (DAST), open-ended questions, and semi-structured interviews. Each tool was implemented twice, before and after the IBR intervention.

DAST is an instrument wherein drawings convey thoughts about scientists. In the DAST, participants draw their perceptions of a scientist on a blank sheet of paper. At the top of the paper is a directive: "Imagine that you are going to visit a scientist tomorrow. Draw this scientist along with her/his environment in the space provided below."



Fig. 1 Example of a page from the IBR intervention book

For this research, drawing was an advantage for the selected participant group, as their vocabulary may be limited due to age. To enhance the precision and comprehensibility of the drawings, the students were given three open-ended written questions asking them to explain their drawings. These questions concerned the scientist's gender, workplace characteristics (indoor, outdoor, classroom, and laboratory), and the kind of work this scientist did. Moreover, interviews were conducted with ten volunteers before the pre- and post-administration of DAST. The objective was to clarify the drawings and written explanations of the students. Interview questions were developed based on the DAST checklist (see Data analysis) items. Interviews lasted between 13 and 15 min. Open-ended questions and interviews enabled us to triangulate the data from the DAST drawings and provide a more comprehensive picture of the images of scientists that children hold.

6.7 Data Analysis

The data obtained from the drawings of the students was analyzed with the Draw-A-Scientist Test Checklist (DAST-C) developed by Finson et al. (1995). DAST-C contains 15 independent items depicting the traditional images of scientists. Regarding the coding of the items, the presence of features reflecting the stereotypical image of the scientist was coded as 1, whereas their absence was coded as 0. According to the DAST-C, participants received a score ranging from 0 to 15, indicating that the higher the score, the more stereotypical images of scientists.

For the first research question aimed to uncover students' images of the scientists' appearance, the items of lab coats, eyeglasses, unusual hairstyles or beards, mythical stereotypes, ethnicity, and an elderly scientist were considered. The presence of these items was coded as 1, while their absence was 0, and the total score regarding the scientist's appearance was obtained from the sum of these DAST-C items' scores. In the second research question, symbols of research (scientific instruments, lab equipment of any kind), symbols of knowledge (book, article, etc.), technology (missiles, etc.), relevant captions (formulae, etc.), indications of danger, presence of light bulbs, indications of secrecy, and scientist working indoors items were used. Their presence was coded as 1, whereas their absence was coded as 0. The scores obtained from each item were calculated, which gave the total score pertaining to the scientist's workplace. Regarding the last research question concerning the scientists' gender, the male scientist in the student drawings was coded as 1, whereas the female scientist was coded as 0. Student responses to the open-ended and interview questions were analyzed to increase the understandability of the drawings. For instance, responses to these questions of the same participant were consulted to verify the presence of suspected DAST-C items in the drawings. An example of the coding procedure is provided in Fig. 2 below, with the pre-drawing of S6.

The pre-intervention drawing of S6 was coded as 1 point for the following items: lab coat, eyeglasses, hair and face, lab equipment, formulae, workplace, gender, and ethnicity (these eight characteristics are specified as underlined codes in Fig. 2). In contrast, these items scored 0 in the post-intervention drawing which is provided in Fig. 3.

The DAST data was coded by two researchers. For the first turn, researchers coded three drawings separately. The degree of agreement was calculated as 88.9% (Miles & Huberman, 1994). After discussing their disagreements (e.g., symbols of knowledge and technology) and reaching a consensus on the coding, the rest of the data were coded. The final degree of agreement was calculated as 94.4%.

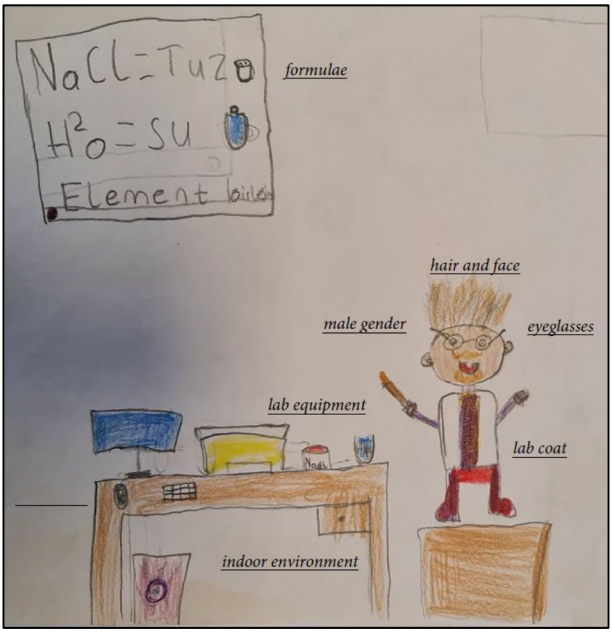


Fig. 2 Example from coding of a scientist's characteristics from pre-drawing of S6

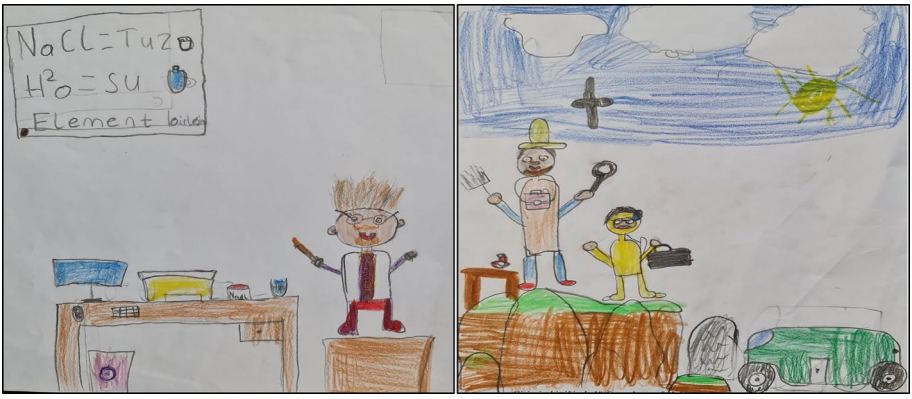


Fig. 3 Pre-and post-intervention drawings of S6

6.8 Trustworthiness

In this study, the research process was attempted to be explained in as much detail as possible to provide trustworthiness. The voluntary participation of the students was taken on as a basis. Efforts were made to establish a relationship based on mutual trust with the participating students. For this reason, the students participated in the data collection process in their own classrooms. During this process, we worked with the participating students' class teachers to obtain accurate and thorough answers as children felt more comfortable

with their teachers. Throughout the research process, three science educators and two qualitative researchers were consulted to evaluate the study based on their fields of expertise. The data triangulation technique was used to increase the internal validity of the research. Within this insight, two data collection methods were used (interviews, open-ended questions, and the DAST), and findings were derived by comparing the data collected through them. Accordingly, the weaknesses of one method were compensated by the strengths of the other. The DAST data were coded by two separate researchers, and the analysis results were compared to provide consensus on the coding. To demonstrate the confirmability of the study, direct quotes from the semi-structured interview data were presented in the findings section. Thus, the participants' own statements were included in the findings instead of the researcher's prejudices or opinions.

7 Findings

7.1 Changes in Students' General Images of Scientists

In this section, students' general images of scientists are presented. DAST-C scores regarding scientists' characteristics before and after the IBR intervention are given in Table 3.

According to the DAST-C, students receive a score of either 0 or 1 for each item related to scientific characteristics. It is considered that as the total score increases, students' perceptions align more closely with the stereotypical image of a scientist. As illustrated in Table 3, the total DAST-C scores of all students were 79 and 46 during the pre- and post-intervention, respectively. This indicates that students' images of scientists shifted from more stereotypical to less stereotypical after the IBR intervention. Notably, three items—working indoors, elderly scientists, and lab coats—showed significant changes, becoming less stereotypical from pre- to post-scores. However, there was a slight shift towards the stereotypical image in items related to symbols of knowledge and indications of danger.

The pre- and post-IBR scores for each student are provided in Table 4. When the change in total DAST-C scores was examined individually, a decrease was observed in 10 of the 12 students participating in the study, indicating a transition to a less stereotypical scientist image. On the contrary, the post-IBR scores of two students increased compared to their pre-IBR scores.

The highest decline was found in S6, with 9 points. Pre- and post-intervention drawings of S6 are presented in Fig. 3.

As it is provided in Fig. 3, the pre-intervention drawing of S6 was coded as 1 point for the items regarding the lab coat, eyeglasses, hair and face, lab equipment, formulae, workplace, gender, ethnicity (these eight characteristics were specified from the drawings), technology, symbols of knowledge, light bulb, and age (these characteristics are clarified by the student in the interviews). In contrast, these items scored 0 in the post-intervention drawing, which caused a 9-point decline in total. Symbols of knowledge, gender, ethnicity, indications of danger, mythical stereotypes, and indications of secrecy among the DAST-C items did not show any changes in the pre- and post-intervention drawings of S6. In both drawings, S6 depicted a white male scientist without symbols of secrecy and danger.

An increase was observed in the total DAST-C scores of only two students. Scores for S7 and S12 increased by 2 and 1 points, respectively. When the former student's drawings were examined, an increase was observed due to the inclusion of symbols of knowledge and a light bulb in the post-drawing. In the pre-intervention drawing, S7 drew a person

Table 3 DAST-C scores before and after IBR intervention regarding scientists' characteristics

DAST-C	Characteristics	Pre-IBR	Post-IBR
Appearance	Lab coat	7	0
	Eyeglasses	4	3
	Hair and facial hair	7	4
	Ethnicity	12	12
	Mythic stereotypes	0	0
	Elderly scientist	5	1
	Subtotal score	**35**	**20**
Workplace	Lab equipment	9	3
	Symbols of knowledge	5	6
	Symbols of technology	6	3
	Relevant caption	1	0
	Indication of danger	0	1
	The presence of light bulbs	2	2
	Indications of secrecy	0	0
	Working indoor	11	2
	Subtotal score	**34**	**17**
Gender	Male	10	9
	Total score	**79**	**46**

performing magic in the open air, whereas, in the post-intervention drawing, he portrayed a scientist working on insecticide at a university. In the interview, once S7 was asked why he drew a magician and the relationship between a magician and a scientist, the following conversation took place between him and the researcher:

Researcher: What did you draw? Can you tell me?
Student 7: There is a child. He is placing this here. He is losing.
R: When I told you to draw a picture of a scientist, you said you did not know what a scientist is. In the classroom. You stated you were going to draw a magician. Is that him in this picture?
S7: Yeah, the magician.
R: So, you drew a magician. Do you think a scientist and a magician are the same or not?
S7: It seems the same. I said that because they also do magic. Scientists, I mean.
R: Where did you learn that? Scientists do magic…
S7: From TV.
R: Did you draw a magician because you thought a magician and a scientist were the same?
S7: Yes.

As can be noticed in Table 3, when the total DAST-C scores pre- and post-IBR intervention were evaluated in terms of scientists' characteristics, the most crucial change was in the item of workplace of scientists, with a 9-point decrease. The least change was observed in the formulae, gender, and scientists with eyeglasses items with a decrease of 1 point and in the indication of danger item with a 1-point increase. However, no indication of secrecy or mythic (legendary) scientists was discovered in any drawings before or after the intervention. In addition, none of the students drew scientists from different ethnic backgrounds. The scientists drawn were all white (Caucasian) people.

Table 4 Important changes in DAST-C scores before and after the IBR intervention by students

Student	Change in scores	Appearance		Workplace		Gender	
		Pre-IBR	*Post-IBR*	*Pre-IBR*	*Post-IBR*	*Pre-IBR*	*Post-IBR*
S6	Highest decrease in appearance, workplace and total score	**5**	**1**	**6**	**0**	1	1
S12	Increase in total score	**2**	**3**	**4**	**4**	**1**	**1**
S7		**1**	**1**	**0**	**2**	**1**	**0**
S5	Decrease in gender score	3	3	2	0	**1**	**0**
S4	Increase in gender score	4	1	2	1	**0**	**1**
S8		3	2	4	3	1	1
S1		3	1	2	1	1	1
S9		3	1	2	1	1	1
S11		4	2	2	1	1	1
S3		4	2	2	0	0	0
S2		1	1	4	3	1	1
S10		2	2	4	1	1	1
Total		**35**	**20**	**34**	**17**	**10**	**9**

Colors indicate the explanations in the second row of the table (i.e. change in scores). For instance, green color indicates *increase in gender score*

7.2 Changes in Students' Images of Scientists' Appearance

The first research question concerned the students' images of scientists' appearance. As shown in Table 4, the total score obtained from the DAST-C items for the appearance of a scientist in the pre-IBR intervention was 35, whereas it was 20 after the intervention. Some student drawings attracted attention when the changes in the images of scientists' appearance were evaluated individually. Pre- and post-IBR drawings of S4 are presented in Fig. 4.

The scientist in S4's pre-IBR drawing had the characteristics of a traditional scientist image with eyeglasses, upright hair, and a white lab coat. By contrast, the scientist in the post-IBR was pictured as a person without eyeglasses, upright hair, and a coat but with a blue shirt. For the scientist in the pre-drawing, the student commented, "…he wears eyeglasses. Her hair is white. He wore a shirt, a lab coat…" Regarding the post-IBR drawing, he declared, "…he is young. He is tall." The drawings and comments suggest that S4's image of the scientist's appearance has changed from traditional to non-traditional.

The following example is pre- and post-IBR drawings of S5, seen in Fig. 5. In this student's pre- and post-IBR drawings, the scientist also has upright and messy hair. In the pre-IBR interview, he described the scientist as "…the centuries-old. I mean, he is really old. He is ugly, as well…." After the intervention, he remarked, "…He wears eyeglasses… He is young… with a black jacket…." It is understood from these findings that the student significantly changed his perception of scientists, particularly regarding their age. Moreover, unlike his pre-IBR drawing, S5 did not refer to the scientist as ugly in his post-drawing.

7.3 Changes in Students' Images of the Scientists' Workplace

The second research question was about students' images of scientists' workplaces. As given in Table 4, the total score obtained from the DAST-C items regarding the scientist's working environment before the IBR was 34, which decreased to 17 after the intervention. When the items in Table 4 were examined separately, it was seen that there were significant changes in the scores of two items, symbols of research and scientists working indoors. Before the IBR, nine students drew laboratory instruments; yet, after the intervention, they were found solely in three students' drawings. As for the item, scientists working indoors, eleven students drew scientists in an indoor setting like a laboratory or classroom before the IBR. On the contrary, just two students drew scientists indoors after the IBR.

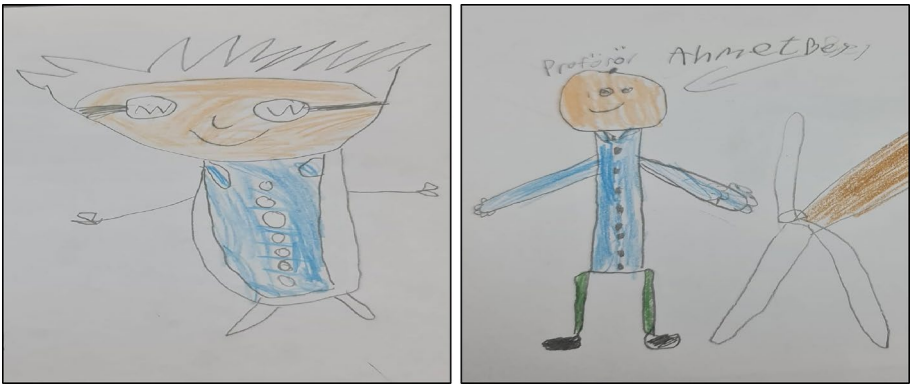


Fig. 4 Pre-and post-IBR drawings of S4

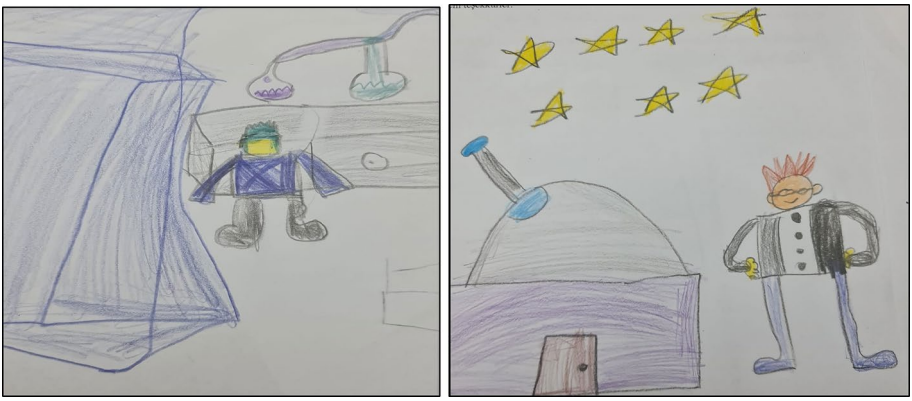


Fig. 5 Pre-and post-IBR drawings of S5

Specifically, most students imagine scientists working outside, such as at the beach or an excavation site.

Upon examining the variations in the students' drawings of scientists' workplaces, certain ones stood out. As an example, Fig. 3 shows pre- and post-IBR drawings of S6. In his pre-IBR drawing, a traditional laboratory (indoor environment) with laboratory instruments, formulas drawn on the whiteboard, technological devices such as computers, and information symbols were found regarding the scientist's workplace. Analysis of the post-IBR drawing of the same student revealed that the environment in which the scientist worked was utterly distinct from the previous one. In his post-IBR drawing, S6 depicted the scientist as an archaeologist searching for remains in the field (outdoor environment).

In the interview before IBR with S6, he stated, "…he is lecturing to the class. So, this man works in a school… There is a chemistry laboratory in the school. He tells the children about the compositions of the elements… He has a stick in his hand, a pointer stick… There is water. There is salt. It says NaCI on it." Afterward, the researcher asked, "There is a formula of NaCl in your drawing. How do you know about NaCI?" He replied, "I once came across it in a computer game. I remember it from there. Actually, I am interested in history and geography." The following statements belonged to the same student's post-IBR interview data: "In this picture, the scientist is looking for ruins outside. Next to him is my friend. My friend is also a friend of the scientist. He brought my friend along with him. They work together." The researcher asked, "Why did you draw these ruins?" He answered the question, "These are ancient ruins. Orkhon inscriptions.He is an archaeologist doing excavation. These are my areas of interest, too. Maybe I can be a scientist researching these. This is the camera (showing the camera on the drawing). They will take photos of the ruins. The computer is in my friend's hands. They will store the findings there, as well." During the pre-IBR interview, he mentioned that his drawing illustrated a stereotypical workplace (chemistry laboratory) and an image of a scientist. However, in the post-IBR interview, he emphasized the non-stereotypical workplace (an outside area) and the behaviors of a scientist, an archaeologist collecting data, storing it, and working outdoors. Aside from this, he pointed out his desire to become a scientist and included his friend in the narrative.

As another example, the pre- and post-IBR drawings of student S8 are displayed in Fig. 6. According to his pre-IBR drawing and the interview, the scientist is attempting to

develop a medicine to treat the plague virus by operating a lab apparatus. The drawing also includes symbols of knowledge and technology. His post-IBR drawing also contains the same symbols. On the other hand, the most apparent difference between the two drawings is that the scientist in the pre-IBR drawing is trying to develop medicine in a laboratory (an indoor setting). In contrast, in the post-IBR drawing, he is an oceanographer researching fish in the ocean (an outdoor setting).

Details from S8's drawings concerning the imagined scientist's workplace were revealed in pre- and post-IBR interviews. In the pre-IBR interview, S8 described his pre-IBR drawing, "…there are laboratory mice. There is a computer. There is acloset…, ascience room… for experiments.Colorful ones are medicines." In response to this student's statement, the researcher posed the following questions: "What will the scientist do with these mice? Why did you draw these mice?" He declared, "Sohe is inventing something like medicine. It is a virus or something else. He is doing something to recover them. He gives viruses to mice and then sees which one recovers. He writes them into the computer. I mean, the ones that are recovered." The interview results supported the finding that he considerably included research symbols in his pre-IBR drawing, such as scientific instruments and laboratory equipment. The following statements are from the interview with the same student after the IBR, "The scientist is in the ocean. It is in the ocean, but it is like a base… It is an ocean, but it is a protected place… He looks at the fish species… He groups them… There are fish species there. Megalodon, for example. Megalodon is the largest fish in the world… I am interested in fish species." We can conclude that he depicted the scientist as working indoors in the pre-interview. However, he changed his idea in the post-interview and imagined the scientist as someone who can work outdoors.

7.4 Changes in Students' Images of the Scientists' Genders

The third research question of the study concerned the students' images of scientists' genders. The question aimed to reveal how the IBR affected students' perceptions of scientists' genders. As provided in Table 4, while 10 of the students drew the scientist as male at the pre-IBR intervention, it was observed that this number decreased to 9 at the post-IBR. According to this data, there was a 1-point increase in the number of students portraying scientists as women after the IBR. During the interviews, students were asked to indicate the gender of the scientist in their drawings and the reason for choosing that gender. When the DAST-C item regarding the scientist's gender was examined individually, the change in

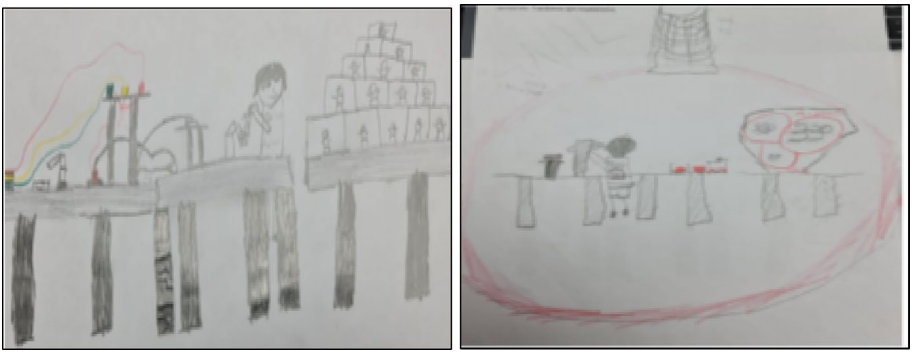


Fig. 6 Pre-and post-IBR drawings of S8

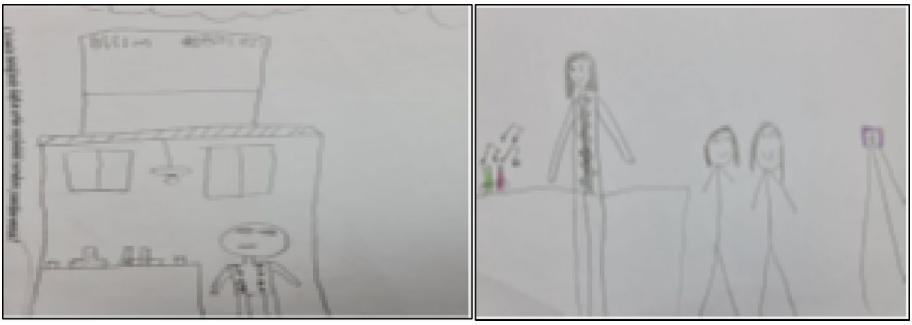


Fig. 7 Pre-and post-IBR drawings of S1



Fig. 8 Pre-and post-IBR drawings of S9

some students was noticeable. For example, pre- and post-IBR drawings of Student 1 are presented in Fig. 7.

Analyzing the drawings in Fig. 7, it was uncovered that the S1 drew the scientist as a male in the pre-IBR drawing, whereas the post-IBR drawing showed the S1 portrayed the scientist as a female, and moreover, more than one in number. In the pre-IBR interview, she expressed, "his gender is male… becausethat iswhat happens…." However, in the interview after the IBR, she reported, "I drew a girl because I thought I could be a scientist too. Short hair. If her hair werelonger, she would have to tie it up." As another example, S9's pre- and post-IBR drawings are presented in Fig. 8.

The drawings in Fig. 8 revealed that S9 drew two scientists, a man and a woman, in the pre-IBR drawing. However, in the post-IBR drawing, she depicted a group of scientists consisting only of women presenting their research findings to each other. Her interview data regarding the third research question confirms this result. When the student's pre-IBR interview data was examined, she commented, "The one with blue hair is a man. The woman has got pink hair. The man has got short hair. They are both adults. The woman has tied her hair in two ponytails… So, there is no such thing as all of them are men. It can be a woman and a man." With regard to the student's post-IBR data, she described her drawing, "Here on the third floor, a female scientist is making a presentation about plants.

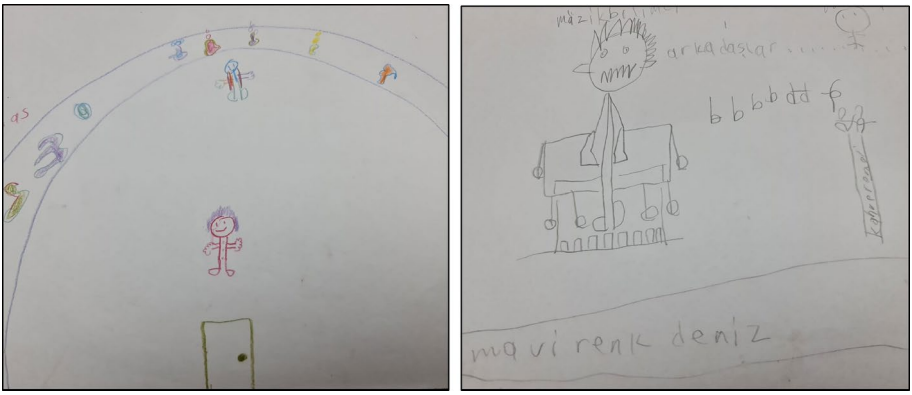


Fig. 9 Pre-and post-IBR drawings of S3

Anotherfemalescientist on thesecond floor researched new plants and grew them. She also examined animals. She explored seashells and sea animals, as well. They make presentations to each other, girl to girl. That is excellent."

S3 was the only student who drew a female scientist in the pre-drawing and altered it to a male scientist after the intervention. In the pre-drawing, he drew a woman working in the laboratory with tubes and preparing mixtures to discover teleportation. In the post-drawing, he drew a male musicologist working at the beach with his friends. The drawings of S3 are given in Fig. 9.

8 Discussion and Conclusion

The present study explored the second-grade primary school students' images of scientists through the IBR intervention. The data was collected via DAST, and interviews were conducted with students before and after the intervention. Overall, research findings have shown that the IBR intervention highly affects students' images of scientists. The number of stereotypical features of scientists in post-IBR drawings was notably lower than in pre-IBR drawings, suggesting that the IBR intervention has a considerable effect on students' images.

The research results have also revealed that even though many elements of the stereotypical image of a scientist disappeared in students after IBR, there was no change in students' images regarding gender and ethnicity. Although the scientist in the IBR book was a woman, more students kept drawing the scientist as a man instead of a woman. Despite the literature indicating that students' stereotypical images of scientists can be transformed through a variety of interventions (Bodzin & Gehringer, 2001), it has also revealed that primary school students still question whether women are really scientists and that bias against scientists' gender cannot be overcome readily (Buck et al., 2002; Chambers, 2022; Miller et al., 2018a, 2018b). The persistence of children to perceive scientists as male may result from various cultural, societal, and media influences. Historically, the most prominent scientists presented in textbooks, media, and popular culture have predominantly been male (Steinke et al., 2009). In addition, societal norms have traditionally associated men with careers in science and technology fields. Despite the growing presence of female scientists, a gap in visibility and recognition remains.

A further finding in the current study is the differences in the students' images of scientists, particularly regarding their workplaces. Almost all of the scientists in the pre-IBR drawings were represented as working indoors, whereas only two scientists were portrayed working indoors in the post-IBR drawings. The substantial changes in the students' images of scientists can be attributed to the representation of scientists working in a variety of settings in the IBR book (Baker & Jarman, 2008). As such, scientists in the book were featured in a music room, an excavation site, or at sea. Similarly, in the post-interviews, children mentioned scientists, such as an archaeologist conducting an excavation or an oceanographer studying fish in the ocean. Additionally, the students drew many research symbols in the pre-drawing, such as lab equipment, while they included fewer symbols in their post-IBR drawings. The outdoor settings in the drawings also varied in that the students pictured scientists working at the seaside, at the excavation site, at the congress area, and in research areas such as the observatory. This finding implies that students' perceptions of scientists having different fields of specialization and not having fixed research methodologies have improved (Miller et al., 2018a, 2018b; Steinke, 2013). Furthermore, scientists in three-quarters of the pre-IBR drawings used some symbols of research, most of which were laboratory equipment and scientific instruments or similar tools. The number of students who included symbols of research in their post-drawings decreased to one-fourth. This difference emerged due to the fact that students drew scientists out of the laboratory in particular and represented them in more distinct work environments. Further, more symbols of knowledge, particularly books, were noticed in the children's post-drawings. The excessive representations of symbols of knowledge (the outcomes of science) in the post-drawings indicate that children tend to perceive science as a collection of static facts (Miller, 2013). Children in this age group interact frequently with symbols of knowledge like books, which may be the underlying reason.

Another significant finding is indications of danger and secrecy, and scientific symbols were rarely represented in pre- and post-drawings. This suggests that children contradict the stereotypical image of scientists in terms of their way of portraying the work environment and that they have a positive perception of science. Additionally, especially in the post-drawings, children depicted many scientists researching social sciences such as archaeology and history. The relevant literature indicates that children rarely picture scientists when dealing with social sciences (Blagdanic et al., 2019). This finding of the current study can be deemed a significant indication that the IBR intervention, carried out with a meticulously selected children's book, leads children to consider and internalize the fact that scientists study a wide range of topics.

In the children's pre-drawings, scientists were depicted as old with messy hair and beards, wearing lab coats, and as unpleasant characters, whereas in the post-intervention drawings, none of the scientists wore a coat, and almost all of them were illustrated as young and friendly personalities. Also, all scientists in the drawings were represented as Caucasians, and students drew no well-known or legendary scientist like Einstein. While it is disappointing that all the scientists depicted in students' drawings are of Caucasian, this can be attributed to the book used for the IBR intervention, which lacked representation of scientists from diverse racial backgrounds, highlighting a potential deficiency in the content of the book. Incorporating books that feature individuals from diverse ethnic backgrounds can aid students in forming images of scientists from various racial groups. Another underlying reason for this case could be that the population in the region where the intervention was conducted is not cosmopolitan; it is unlikely that children will encounter individuals from different backgrounds throughout their lives. A possible explanation for such a situation may be accepting the impact of the socio-cultural environment with which children interact on constructing traditional images of scientists (Clark, 1994; Oguz, 2010; Sharkawy, 2012). As

an example, Farland-Smith (2009b) conducted a study with children from different cultures that found cultural experiences influence children's perceptions of scientists. Nevertheless, these justifications do not alter the existing fact that children have stereotypical perceptions of scientists' ethnicity. This result corroborates the findings of the recent research on children's images of scientists (Kelly, 2018; Rawson & McCool, 2014). Most of the children's drawings were consistent with the traditional stereotypical image of scientists in terms of ethnicity and gender. Nonetheless, they differed considerably regarding other physical characteristics such as age, lab coat, glasses, hair, and beard style. Several non-stereotypical depictions of scientists (young and without lab coats) were identified in their drawings. It is also noteworthy that none of the drawings contained elements of mythic stereotypes (crazy, out of control).

However, the stereotypical image that associates scientists with white males has dominantly persisted. This finding is consistent with previous studies examining children's books portraying the characteristics of scientists (Ford, 2006; Kelly, 2018). The predominance of this white male scientist image and children's resistance to alter it may restrict girls' interest in science activities and science-related careers with regard to their potential career decisions (Miller et al., 2018a, 2018b). As predicted by some theories of gender development, the belief that one must be a male to become a scientist can subconsciously and negatively affect girls' images (Hyde, 2014). Consequently, science becomes less attractive to them. Authors, teachers, parents, and popular media have a vital role in overcoming this bias. Authors can support young readers by incorporating scientists of different genders and featuring particularly female scientists in their books. Educators and parents, likewise, may offer support for children by being well aware of the stereotypic image of the scientist and selecting books involving images that contradict this image. This issue is significantly critical for younger children, as such books often serve as their initial exposure to the scientific process.

The findings of the present study underscore that the IBR intervention using the children's trade book was successful in reducing the stereotypical images of scientists' appearance and in demonstrating that scientists can work in a range of settings. Therefore, we believe that implementing IBR interventions alongside children's books, which include evident descriptions of scientists, will facilitate children's comprehension of their identities and the nature of their work. Once read-aloud and interactive book reading activities consolidate this portrayal, it contributes to constructing images of scientists in children's minds beyond stereotypical characteristics. Along with all these positive effects, the standard image of scientists as male and the emphasis on symbols of knowledge, which are the outcomes of science, still exist in children. Further, it should be noted that the scope of this study applied limited intervention in the teaching process, such as read-aloud and subsequent discussions about the book. Nevertheless, it can be indeed declared that the results are remarkable, highlighting the crucial role of well-designed children's books as supplemental materials in educating children about scientists and their work.

9 Recommendations for Practitioners and Researchers

Teachers should encourage children to comprehend that people from diverse socio-cultural backgrounds, such as Caucasians, Africans, Asians, and individuals with physical disabilities, can participate in science activities. Children living in non-multicultural settings, as in the present study, should be primary recipients of this encouragement. To achieve this objective, we should deliberately select stories and activities that represent groups traditionally underrepresented in science.

This study and previous studies reveal that children tend to depict women as scientists less often than men, a perception that remains resistant to change. It would serve as a guide for researchers to conduct more comprehensive research on both the origins of this understanding and how to change it. As children develop more inclusive images of science and scientists, they may have the potential to be transformative as potential members of the scientific society of the future.

About 30 million books are published annually in Türkiye (Yayfed, 2023), of which 15% are children's books. The increasing rate of children's books signifies that they will presumably reach more children. Since children learn social norms through media such as television, movies, books, and magazines (Previs, 2016), publishers play a critical role in ensuring the accurate development of these norms in children. Publishers can collaborate with authors for the contents of books encompassing elements pertinent to the images of scientists and endorse works featuring such content. Moreover, publishers can purposefully prioritize narratives and actions that showcase groups that often face limited acceptance as scientists, including women and individuals from diverse backgrounds, in their publications. Furthermore, merely illustrating women engaging in scientific activities in these publications may not suffice. In order to undermine the traditional belief in the role of gender and ethnicity, it is crucial to use scenarios that depict these groups as actively involved in scientific studies. To illustrate, women should not be portrayed solely as assistant scientists (secondary roles) but also as experts in narratives or stories.

Data Availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

References

Allchin, D. (2011). Evaluating knowledge of the nature of (whole) science. *Science Education, 95*(3), 518–542.

Aram, D., Fine, Y., & Ziv, M. (2013). Enhancing parent–child shared book reading interactions: Promoting references to the book's plot and socio-cognitive themes. *Early Childhood Research Quarterly, 28*(1), 111–122.

Arnold, D. H., Lonigan, C. J., Whitehurst, G. J., & Epstein, J. N. (1994). Accelerating language development through picture book reading: Replication and extension to a videotape training format. *Journal of Educational Psychology, 86*(2), 235–243. https://doi.org/10.1037/0022-0663.86.2.235

Avsar Erumit, B., & Akerson, V. L. (2022). Using children's literature in the middle school science class to teach nature of science. *Science and Education, 31*, 713–737. https://doi.org/10.1007/s11191-021-00274-3

Baker, D. R., & Jarman, R. (2008). The impact of inquiry-based learning on students' images of scientists: Evidence from the field. *Journal of Science Education and Technology, 17*(3), 292–301. https://doi.org/10.1007/s10956-008-9123-5

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of science and mathematics education*. Horizon Research Inc.

Barman, C. R. (1999). Students' views of scientists and science: Results from a national study. *Science and Children, 36*(7), 18–24.

Blagdanic, S., Kadijevic, G. M., & Kovacevic, Z. (2019). Gender stereotypes in preschoolers' image of scientists. *European Early Childhood Education Research Journal, 27*(2), 272–284. https://doi.org/10.1080/1350293X.2019.1579551

Bodzin, A., & Gehringer, M. (2001). Breaking science stereotypes. *Science and Children, 39*(1), 36–41.

Bozzato, P., Fabris, M. A., & Longobardi, C. (2021). Gender, stereotypes and grade level in the draw-a-scientist test in Italian schoolchildren. *International Journal of Science Education, 43*(16), 2640–2662.
Brochey-Taylor, J., & Taylor, J. A. (2024). Synthesizing validity and reliability evidence for the Draw-A-Scientist Test. *Educational Research and Reviews, 19*(3), 44–52.
Brunner, J. L., & Abd-El-Khalick, F. (2020). Improving the nature of science instruction in elementary classes with modified science trade books and educative curriculum materials. *Journal of Research in Science Teaching, 57*(2), 154–183.
Buck, G. A., Leslie-Pelecky, D., & Kirby, S. K. (2002). Bringing female scientists into the elementary classroom: Confronting the strength of elementary students' stereotypical images of scientists. *Journal of Elementary Science Education, 14*(2), 1–9.
Chambers, D. W. (1983). Stereotypic images of the scientist: The draw a scientist test. *Science Education, 67*(2), 255–265. https://doi.org/10.1002/sce.3730670213
Chambers, D. W. (2022). Draw-A-Scientist Test in the 21st century: The evolving role of gender in children's perceptions. *International Journal of Science Education, 44*(1), 12–24. https://doi.org/10.1080/09500693.2021.1990785
Chang, K., Tai, Y., Liu, T., & Sung, Y. (2023). Embedding dialog reading into AR picture books. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2023.2192758
Christidou, V., Bonoti, F., & Hatzinikita, V. (2023). Drawing a scientist: Using the Emo-DAST to explore emotional aspects of children's images of scientists. *Research in Science & Technological Education, 41*(4), 1287–1308.
Christidou, V., Bonoti, F., & Kontopoulou, A. (2016). American and Greek children's visual images of scientists. *Science & Education, 25*, 497–522.
Clark, S. (1994). *A study of children's drawing types and factors influencing choice of subject matter.* Edith Cowan University. https://ro.ecu.edu.au/theses_hons/622. Accessed 2 Jan 2024.
Daisey, P. (1994). The value of trade books in secondary science and mathematics instruction: A rationale. *School Science and Mathematics, 94*, 130–137.
Duncum, P. (1980). Children's spontaneous image-making as play. *Journal of the Institute of Art Education, 4*(1), 1–30.
Emvalotis, A., & Koutsianou, A. (2017). Greek primary school students' images of scientists and their work: Has anything changed? *Research in Science & Technological Education, 36*(1), 69–85.
Ergül, C., Sarıca, A. D., & Akoğlu, G. (2016). Dialogic reading: An effective method to improve language and early literacy skills. *Ankara University Faculty of Educational Sciences Journal of Special Education*, *17* (02), 193–206. https://doi.org/10.21565/ozelegitimdergisi.246307
Eshach, H., & Fried, M. N. (2005). Should science be taught in early childhood? *Journal of Science Education and Technology, 14*(3), 315–336.
Fang, Z. (2010). *Teaching content area reading and writing: A teacher's guidebook*. University of Virginia.
Farland, D. (2006). Trade books and the human endeavor of science. *Science and Children, 44*(3), 35–37.
Farland-Smith, D. (2009a). Exploring middle school girls' science identities: Examining attitudes and perceptions of scientists when working "side-by-side" with scientists. *School Science and Mathematics, 109*(7), 415–427.
Farland-Smith, D. (2009b). How does culture shape students' perceptions of scientists? Cross-national comparative study of American and Chinese elementary students. *Journal of Elementary Science Education, 21*(4), 23–42.
Farland-Smith, D. (2012). Development and field test of a rubric for assessing the Draw-A-Scientist Test. *School Science and Mathematics, 112*(2), 109–116. https://doi.org/10.1111/j.1949-8594.2011.00124.x
Farokhi, M., & Hashemi, M. (2011). The analysis of children's drawings: Social, emotional, physical, and psychological aspects. *Procedia - Social and Behavioral Sciences, 30*, 2219–2224.
Ferreira, C., & Valente, B. (2024). Stereotypes and views of science among elementary students: Gender and grade differences. *International Journal of Education in Mathematics, Science and Technology, 12*(1), 68–84.
Finson, K. D. (2002). Drawing a scientist: What we do and do not know after fifty years of drawings. *School Science and Mathematics, 102*(7), 335–345.
Finson, K. D., Beaver, J. B., & Cramond, B. L. (1995). Development and field test of a checklist for the draw-a-scientist test. *School Science and Mathematics, 95*(4), 195–205.
Ford, D. J. (2005). The challenges of infusing nature of science into trade books. *Journal of Research in Science Teaching, 42*(4), 373–392.
Ford, D. J. (2006). Representations of science within children's trade books. *Journal of Research in Science Teaching, 43*(2), 214–235.
Fung, Y. Y. H. (2002). A comparative study of primary and secondary school students' images of scientists. *Research in Science & Technological Education, 20*(2), 199–213.

Goodenough, F. L. (1926). *Measurement of intelligence by drawings*. Harcourt, Brace, and World.
Harris, D. B. (1963). *Children's drawings as measures of intellectual maturity. A revision and extension of the Goodenough Draw-A-Man Test*. Harcourt, Brace, and World.
Hillman, S. J., Bloodsworth, K. H., Tilburg, C. E., Zeeman, S. I., & List, H. E. (2014). K-12 students' perceptions of scientists: Finding a valid measurement and exploring whether exposure to scientists makes an impact. *International Journal of Science Education, 36*(15), 2580–2595. https://doi.org/10.1080/09500693.2014.908264
Hyde, J. S. (2014). Gender similarities and differences. *Annual Review of Psychology, 65*, 373–398. https://doi.org/10.1146/annurev-psych-010213-115057
Kelly, L. B. (2018). An analysis of award-winning science trade books for children: Who are the scientists, and what is science? *Journal of Research in Science Teaching, 55*(8), 1188–1210. https://doi.org/10.1002/tea.21447
Kletzien S. B., Dreher M. J. (2004). *Informational text in K—3 classrooms.* Newark, DE: International Reading Association.
Leblebicioglu, G., Cetin, P., Dogan, E. E., Peten, D. M., & Capkinoglu, E. (2021). How do science camps affect middle grade students' image of scientists? *Research in Science & Technological Education, 39*(3), 285–305.
Leden, L., Hansson, L., & Thulin, S. (2022). Characteristics of book talks about nature of sccience. *Science Education, 106*(6), 1469–1500.
Lewis, D., & Greene, J. (1983). *Your child's drawings: Their hidden meaning*. Hutchinson.
Losh, S. C. (2010). Stereotypes about scientists over time among US adults: 1983 and 2001. *Public Understanding of Science, 19*(3), 372–382.
McGuire, P., Himot, B., Clayton, G., Yoo, M., & Logue, M. E. (2021). Booked on math: Developing math concepts in pre-k classrooms using interactive read-alouds. *Early Childhood Education Journal, 49*, 313–323.
Mead, M., & Metraux, R. (1957). The image of the scientist among high school students: A pilot study. *Science, 126*(3270), 384–390.
Merga, M. K. (2017). Interactive reading opportunities beyond the early years: What educators need to consider. *Australian Journal of Education, 61*(3), 328–343.
Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage.
Miller, D. I., Nolla, K. M., Eagly, A. H., & Uttal, D. H. (2018a). The development of children's gender-science stereotypes: A meta-analysis of 5 decades of US Draw-A-Scientist studies. *Child Development, 89*(6), 1943–1955. https://doi.org/10.1111/cdev.13039
Miller, J. D. (2013). The impact of science education on children's perceptions of scientists: Analyzing the Draw-A-Scientist Test. *International Journal of Science Education, 35*(8), 1363–1384. https://doi.org/10.1080/09500693.2012.745345
Miller, P. H., Blessing, J. S., & Schwartz, S. (2018b). Gender differences in high-school students' views about science. *International Journal of Science Education, 18*(4), 439–455.
Morrow, L. M. (1996). *Motivating reading and writing in diverse classrooms: Social and physical contexts in a literature-based program*. National Reading Conference.
Neri, E., De Pascalis, L., Agostini, F., Genova, F., Biasini, A., Stella, M., & Trombini, E. (2021). Parental book-reading to preterm born infants in NICU: The effects on language development in the first two years. *International Journal of Environmental Research and Public Health, 18*(21), 11361–11375. https://doi.org/10.3390/ijerph182111361
Newton, L. D., & Newton, D. P. (1998). Primary children's conceptions of science and the scientist: Is the impact of a National Curriculum breaking down the stereotype? *International Journal of Science Education, 20*(9), 1137–1149.
Oguz, V. (2010). The factors influencing children's drawings. *Procedia Social and Behavioral Sciences, 2*(2), 3003–3007.
Okyay, O., & Kandir, A. (2021). The impact of interactive storybook reading programme on scientific vocabulary acquisition by children. *Early Child Development and Care, 191*(13), 2067–2077.
Palincsar, A. S., & Magnusson, S. J. (2001). The interplay of firsthand and text-based investigations to model and support the development of scientific knowledge and reasoning. *Cognition and Instruction* (1st ed., pp. 151-181). Psychology Press.
Previs, K. K. (2016). Gender and race representations of scientists in highlights for children: A content analysis. *Science Communication, 38*(3), 303–327. https://doi.org/10.1177/1075547016642248
Quaglia, R., Longobardi, C., Lotti, N. O., & Prino, L. E. (2015). A new theory on children's drawings: Analyzing the role of emotion and movement in graphical development. *Infant Behavior and Development, 39*, 81–91.

Rawson, C., & McCool, M. A. (2014). Just like all the other humans? Analyzing images of scientists in children's trade books. *School Science and Mathematics, 114*, 10–18.
Sackes, M., Trundle, K. C., & Flevares, L. M. (2009). Using children's literature to teach standard-based science concepts in early years. *Early Childhood Education Journal, 36*, 415–422. https://doi.org/10.1007/s10643-009-0304-5
Saul, E. W., & Dieckman, D. (2005). Choosing and using information trade books. *Science and Children, 42*(6), 36–41.
Schroeder, M., Mckeough, A., Graham, S., Stock, H., & Bisanz, G. (2009). The contribution of trade books to early science literacy: In and out of school. *Research in Science Education, 39*(2), 231–250.
Senocak, E. (2021). *Tanıyorum: Bilim insanları (I know: Scientists)*. Vizetek.
Sharkawy, A. (2012). Exploring the potential of using stories about diverse scientists and reflective activities to enrich primary students' images of scientists and scientific work. *Cultural Studies of Science Education, 7*, 307–340. https://doi.org/10.1007/s11422-012-9386-2
Steinke, J. (2013). Gender, science, and media: A review of the research. *Science Communication, 35*(1), 116–126. https://doi.org/10.1177/1075547012450680
Steinke, J., Lapinski, M. K., Crocker, N., Zietsman-Thomas, A., Williams, Y., & Caravella, M. (2009). Assessing media influences on middle school–aged children's perceptions of women in science using the Draw-A-Scientist Test (DAST). *Science Communication, 30*(1), 36–64. https://doi.org/10.1177/1075547008326548
Thomas, N., Colin, C., & Leybaert, J. (2019). Impact of interactive reading intervention on narratives skills on children with low socio-economic background. *European Early Childhood Education Research Journal, 27*(6), 837–859.
Toub, T. S., Hassinger-Das, B., Nesbitt, K. T., Ilgaz, H., Weisberg, D. S., Hirsh-Pasek, K., Michnick Golinkoff, R., Nicolopoulou, A., & Dickinson, D. K. (2018). The language of play: Developing preschool vocabulary through play following shared book-reading. *Early Childhood Research Quarterly, 45*, 1–17. https://doi.org/10.1016/j.ecresq.2018.01.010
Valdezmenchaca, M. C., & Whitehurst, G. J. (1992). Accelerating language-development through picture book reading - A systematic extension to Mexican day-care. *Developmental Psychology, 28*(6), 1106–1114.
Vanparys, S., Debeer, D., & Van Keer, H. (2023). What's the difference? Interactive book reading with at-risk and not-at-risk 1st- and 2nd-graders. *Journal of Research in Childhood Education, 38*(2), 295–316.
Wasik, B. A., & Bond, M. A. (2001). Beyond the pages of a book: Interactive book reading and language development in preschool classrooms. *Journal of Educational Psychology, 93*(2), 243–250.
Whitehurst, G. J., Falco, F. L., Lonigan, C. J., Fischel, J. E., DeBaryshe, B. D., Valdez-Menchaca, M. C., & Caulfield, M. (1988). Accelerating language development through picture book reading. *Developmental Psychology, 24*(4), 552–559. https://doi.org/10.1037/0012-1649.24.4.552
Williams, C. L., & McLean, M. M. (1997). Young deaf children's response to picture book reading in a preschool setting. *Research in the Teaching of English, 31*(3), 337–366.
Woods-Townsend, K., Christodoulou, A., Rietdijk, W., Byrne, J., Griffiths, J. B., & Grace, M. M. (2015). Meet the scientist: The value of short interactions between scientists and students. *International Journal of Science Education, Part B, 6*(1), 89–113.
Yayfed (2023). Yayımcı Meslek Birlikleri Federasyonu Yıllık Değerlendirme Raporları (Federation of Turkish Publishers' Professional Associations Annual Evaluation Reports).. Retrieved 31 Dec 2023.https://www.yayfed.org/yillik-degerlendirme-raporlar
Zeece, P. D. (1999). Using literature to support emergent science literacy in young children. *Early Childhood Education Journal, 26*(3), 161–166.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.