Journal of Educational Sciences, XXVI, 1(51) DOI: 10.35923/JES.2025.1.01

Received: 22.05.2025
Revised: 16.06.2025
Accepted: 14.07.2025
Published: 24.07.2025

Fast and focused: A targeted approach to changing pre-service teachers' images of scientists

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Abstract

Stereotypical imagery of scientists is detrimental to effective and inclusive science education. Many elementary pre-services teachers often hold onto these images, creating an unconscious bias limiting their effectiveness to both teach science content and discourage some groups from entering the scientific field. Proactive and targeted interventions could help mitigate this bias and provide a more inclusive perception of actual scientists. This one-group pretest-posttest quasi-experimental study investigated changes in the perceptions of elementary pre-service teachers regarding scientists. Thirty-three participants completed the Draw-A-Scientist Test before and after a 25-minute intervention aimed at challenging stereotypical views of scientists. The Draw-A-Scientist Test (DAST) checklist assessed participants' depictions of scientists. The results showed a significant reduction in stereotypical imagery post-intervention: 30 participants depicted less stereotypical scientists, while three showed no change. Statistical analysis using the Wilcoxon signed-rank test revealed a significant difference in DAST scores (Mdn = 2 posttest vs. Mdn = 7 pretest, z = -4.805, p < .001). These findings suggest that brief, targeted interventions can effectively alter the naive conceptions of scientists held by elementary pre-service teachers. Implementing such succinct and focused interventions in educator preparation programs may foster more inclusive representations of scientists, potentially inspiring diverse student populations to envision themselves as scientists. This research provides a foundation for promoting accurate and varied representations of scientists in education without the need for significant curricular modifications. The findings of this study indicate that once deficits are identified, well-designed, brief, and targeted interventions can alter elementary pre-service teachers' perceptions, setting the foundation for accurate and inclusive science instruction at the elementary level.

Keywords: DAST, Science Education, Scientist Stereotypes

Introduction

Over the past seven decades, considerable research and writings have discussed the stereotypical imagery associated with science and scientists. Elementary pre-service teachers' perceptions influence their approach to science education, affecting their ability

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to foster an inclusive learning environment and promote an accurate depiction of scientists to their students (Howitt, 2007). Pre-service teachers often form stereotypical images of scientists, influenced by popular culture and limited exposure to scientific work. This can unintentionally perpetuate misconceptions about who can become a scientist and what scientific endeavors truly involve (Ateş et al., 2020). Teachers with stereotypical images of scientists can develop unconscious biases that impact their teaching practices and instructional activities, potentially discouraging underrepresented groups from pursuing careers in science (Hand et al., 2017). Assignments and interventions highlighting the contributions of women and minority scientists can help counter stereotypes. These initiatives can reduce student biases, improving their ability to connect with scientists (Rhinehart, 2022).

The underrepresentation of certain demographics, such as women and minorities, in scientific fields is a pressing issue that necessitates proactive intervention (Rodriguez et al., 2021). Teacher-led interventions focusing on cultural and gender diversity in science can significantly reduce negative stereotypes of scientists in young children, with some changes persisting in the long term (Shimwell et al., 2021).

This study examined the impact of an educational intervention on the perceptions of elementary pre-service teachers regarding scientists. By using the Draw a Scientist Test (Chambers, 1983), the study sought to assess changes in pre-service teachers' perceptions before and after a targeted intervention training. Stereotypical imagery of scientists has been pervasive throughout this term (Finson, 2002; Finson, et al.,1995; Medina-Jerez, et al., 2011; She, 1995) coupled with limited exposure to science education in elementary school (Plumley, 2019). Understanding the factors that make science curriculum relevant can help improve learning and interest in science while respecting diversity and promoting citizenship (Christidou, 2011).

Literature Review

A student's educational experience and cultural depictions shape and influence their perceptions of scientists. These stereotypical views often involve depictions of white males, which has the potential to discourage diverse groups from entering STEM careers (Rhinehart, 2020). The stereotypical scientist imagery, often depicted by a white male, is reinforced in various media sources and educational materials (Rhinehart, 2022). Even as women are more represented in science, children still associate science with men. This association becomes more pronounced as they age, suggesting that science is still perceived as a male-dominated field (Miller et al., 2018).

The manner in which scientists are represented in the classroom, whether intentionally or unintentionally, shapes how students perceive scientists (Ivgin et al., 2021). Narrow scientific stereotypes, often reinforced by media and educational materials, portray scientists primarily as male figures in lab coats, isolated in laboratories, overlooking the diverse reality of scientific work (Chimba & Kitzinger, 2009). These biases can deter underrepresented groups from participating in the scientific community, thereby reducing the diversity and inclusivity of the scientific workforce (Cheryan et al., 2015; Williams et al., 2019).

Interventions aimed at countering stereotypical views of scientists emphasize scientific literacy, including discussing scientific processes by diverse scientists (Kelp et al., 2023). When educators address these misconceptions directly, they can effectively neutralize stereotypical portrayals and promote a more accurate understanding of the scientific process (Borah & Cook, 2017). Conducting targeted interventions focusing on countering these stereotypical scientific perceptions may increase career aspirations among underrepresented groups in the science field (Nguyen & Riegle-Crumb, 2021). Science instruction that emphasizes the human aspect of science highlights the true nature of scientific inquiry. It decolonizes science content and provides a more personal and culturally relevant perspective (Tshuma, 2024).

Educational interventions, followed by appropriate instructional activities that highlight a diverse representation of scientists, can help restructure stereotypical misconceptions. These interventions can foster a stronger individual connection to scientists, increasing individual performance in science courses (Schinske et al., 2016). Fostering a more inclusive educational environment by incorporating a more diverse representation of scientists can combat male-dominated stereotypes in science (Rhinehart, 2022). Interventions by well-trained elementary school teachers can challenge and reshape stereotypical views of scientists (Shin et al., 2015). Targeted professional development programs that promote diverse representations of scientists—such as more female scientists and those working outside traditional labs—enhance students' understanding and appreciation of science as a career (Shea, 2018).

The Draw-A-Scientist Test (DAST; Chambers, 1983) is utilized in educator preparation programs to determine preconceived and stereotypical conceptions of preservice teachers (Miele, 2014; Shea, 2018). Interventions and activities involving DAST improve preservice teachers' understanding of inquiry-based science and alter their beliefs (Eckhoff, 2017). The DAST, used as a reflective exercise, allows preservice teachers to acknowledge their biases and stereotypes about scientists, reconstructing their beliefs, pedagogy, and attitudes toward science (Miele, 2014). Stereotypical perceptions of scientists vary in educator preparation programs, with secondary science method students generating fewer stereotypical representations than elementary science method students (Milford & Tippet, 2013).

Research Purpose, Questions, and Hypotheses

When students are given opportunities to learn about scientific endeavors, they are more likely to appreciate the diverse nature of scientists and their work (Rosenthal, 1993). How teachers discuss science can impact their students' interest in science-related studies and careers (Christidou, 2011). Pre-service teachers who understand scientists accurately are more likely to promote inclusivity in science careers, while those with negative or stereotypical views may discourage students from pursuing scientific careers (Milford & Tippett, 2012). The purpose of this study was to assess the changes in elementary pre-service teachers' perceptions of a scientist's appearance and behavior following a 25-minute intervention. This targeted intervention was designed to challenge stereotypical depictions of scientists, as evaluated through the Draw-A-Scientist Test (DAST). Using the Wilcoxon signed-rank test for pretest and posttest scores and the McNemar test for each sub-category, the study sought to evaluate the impact of targeted interventions on promoting more inclusive and diverse views of scientists among pre-service teachers.

This study asked 33 elementary pre-service teachers (E-PST) to complete the Draw-A-Scientist Test (DAST; Chambers, 1993) before and after a 25-minute targeted intervention to promote more inclusive and diverse representations of scientists and their work.

The following overarching question evolved from the study's problem and purpose: What is the impact of a 25-minute targeted intervention promoting inclusive and diverse representations of scientists on E-PST's perceptions of a scientist's appearance and behavior, as measured by the Draw-A-Scientist Test (DAST)?

RQ1: Is there a statistically significant difference in E-PST 's perceptions of a scientist's appearance and behavior, as measured by the Draw-A-Scientist Test (DAST), before and after a 25-minute intervention?

$H_0$1: There is no statistically significant difference in the pretest and posttest DAST scores following the intervention.

$\mu_1 = \mu_2$

H_a1: There is a statistically significant difference in the pretest and posttest DAST scores following the intervention.

$\mu_1 \neq \mu_2$

RQ2: Is there a statistically significant difference between the proportion of stereotypical depictions of a scientist's appearance among E-PSTs?

$H_0$2: There is no statistically significant difference in the proportion of stereotypical depictions of a scientist's appearance following the intervention.

$\mu_1 = \mu_2$

H_a2: There is a statistically significant difference in the proportion of stereotypical depictions of a scientist's appearance following the intervention.

$\mu_1 \neq \mu_2$

RQ3: Is there a statistically significant difference between the proportion of depictions of a scientist's behavior among E-PSTs?

$H_0$3: There is no statistically significant difference in the proportion of depictions of a scientist's behavior following the intervention.

$\mu_1 = \mu_2$

***H_a*3:** There is a statistically significant difference in the proportion of stereotypical depictions of a scientist's behavior following the intervention.

$\mu_1 \neq \mu_2$

Methodology

Participants

During the fall semester, thirty-five E-PSTs enrolled in a southeastern educator preparation program from a convenience sample were invited to participate in this study. In total, n = 33 elected to participate, where twenty-five were between the ages of 18-22, twenty-nine were female, one was non-binary, and twenty- eight were white (Table 1).

Table 1

Participant Descriptive Data

	N	Percentage		N	Percentage
Age			**Gender**		
18-22	25	75.8	Male	3	9.1
23-27	8	24.3	Female	29	87.9
			Non-Binary	1	3
Race			**Previous Science Courses**		
Black or African American	4	12.1	1-2	6	18.2
White	28	84.8	3-4	20	60.6
Non-Specified	1	3	5 or more	7	21.2

Note. N = 33

Study Design, Instrumentation, and Intervention

This study utilized a one-group pretest-posttest quasi-experimental design to examine the impact of a 25-minute targeted intervention on E-PSTs' perceptions of scientists. The participants were asked to complete the Draw-A-Scientist Test (DAST) both before and after the intervention. The intervention aimed to challenge and diminish stereotypical portrayals of scientists by promoting more diverse and inclusive representations. Each participant was given the DAST template (Appendix A) and instructed to close their eyes and draw an image of a scientist at work. These drawings were collected before the intervention.

During the intervention, E-PSTs were provided with 14 photos of both traditional and non-traditional scientists. These photos showcased a diverse range of scientists, including famous traditional scientists such as Albert Einstein, Francesco Redi, Charles Darwin, and Werner Heisenberg, as well as the non-traditional scientists (Table 2).

Table 2

Non-Traditional Scientists and Contributions

Scientist/Individual	Field	Contribution
Hedy Lamarr	Actor, Model, Inventor	Co-invented frequency-hopping spread spectrum technology, a precursor to modern wireless communication (Wi-Fi, Bluetooth).
Ada Lovelace	Mathematician and Computing Pioneer	Developed the first algorithm intended for Charles Babbage's Analytical Engine, making her the first computer programmer. The first programming language was named "Ada" to honor her contributions.
Mary Anning	Paleontologist	Discovered the first complete Ichthyosaurus skeleton, significantly advancing the field of paleontology.
Dr. Temple Grandin	Animal Behaviorist, Inventor, and Autism Advocate	Revolutionized humane livestock handling systems and advocated for autism awareness and neurodiversity. Created the center track restrainer system and the curved loading chute.
Dr. Marie Maynard Daly	Biochemist	First African American woman in the USA to earn her PhD in chemistry (1947). Conducted research on cholesterol and heart disease, contributing to advancements in biochemistry and medicine
Prince	Musician and Inventor	Designed the keytar, blending electronic music technology with traditional live performance techniques. Created the "Minneapolis" sound by blending funk, R&B, electronic and rock music.
Steve McQueen	Actor and Inventor	Contributed to the development of the bucket seat, improving safety and ergonomics in high-performance vehicles
Julie Newmar	Actor, Model, and Inventor	Patented innovative clothing designs, including pantyhose with a specialized seam for better fit and comfort.
Zeppo Marx	Actor and Engineer	Part of a research team that received multiple patents, including one for a heart rate monitor, showcasing contributions to engineering and medical technology.
Dr. Sabrina Gonzalez Pasterski	Theoretical Physicist	A Cuban-American theoretical physicist studying black holes and spacetime. Advocate for women in STEM. The youngest human being to build an airplane, certify it airworthy, and conduct the first flight in that same aircraft.

Following the task of identifying these scientists and explaining their contributions, the researcher provided the names of each individual and elaborated on their scientific achievements. The discussion centered on how these scientists broke barriers and challenged stereotypes, not only through their contributions to science and technology, but also by virtue of their diverse personal backgrounds. E-PSTs were also provided literature that can be utilized in elementary school classrooms to introduce young learners to these scientists (Table 3). The intervention concluded by addressing how stereotypes can dissuade certain demographics from pursuing careers in STEM fields. After the discussion, E-PSTS were again tasked with completing the DAST to assess whether the intervention influenced their perceptions of scientists.

Table 3.
Literature Associated with Non-Traditional Scientists

Scientist/Individual	Book Title	Approximate Reading Level
Hedy Lamarr	Hedy Lamarr's Double Life: Hollywood Legend and Brilliant Inventor	Grades 3-5
Ada Lovelace	Ada Lovelace, Poet of Science: The First Computer Programmer	Grades 3-5
	Ada Byron Lovelace and the Thinking Machine	Grades 4-6
Mary Anning	Dinosaur Lady: The Daring Discoveries of Mary Anning, the First Paleontologist	Grades 2-4
	Stone Girl, Bone Girl: The Story of Mary Anning	Grades 3-5
Dr. Temple Grandin	The Girl Who Thought in Pictures: The Story of Dr. Temple Grandin	Grades 2-5
Dr. Marie Maynard Daly	Marie, The Fantastic Biochemist	Grades Pre-K- 2
Prince	Prince (Volume 54) (Little People, BIG DREAMS)	Grades Pre-K-2
Steve McQueen	McQueen's Machines: The Cars and Bikes of a Hollywood Icon	Grades 5-8
Julie Newmar	The Conscious Catwoman Explains Life On Earth	Grades 5-8
Zeppo Marx	Zeppo: The Reluctant Marx Brother	Grades 5-8

The DAST checklist (Finson et al., 1995) assessed participants' drawings for stereotypical characteristics of scientists' appearance and behavior. Data were analyzed using the Wilcoxon signed-rank test to compare pretest and posttest scores, measuring overall changes in perceptions (Appendix B). The McNemar test was also applied to assess changes in specific sub-categories of stereotypical depictions. The statistical analyses were performed to evaluate the immediate impact of the intervention on altering the perceptions of E-PST towards a more precise and comprehensive portrayal of scientists.

Data Analysis

The data collected from the DAST were analyzed to evaluate shifts in E-PSTs' drawings of scientists before and after the 25-minute intervention. A Wilcoxon signed-rank test was employed to compare pretest and posttest DAST scores, focusing on overall changes in stereotypical depictions. This non-parametric test was selected due to the ordinal nature of the data and the small sample size. A McNemar test was utilized to assess changes in the sub-categories of the DAST checklist (Finson et al., 1995) related to scientists' appearance and behavior. A significance level of $p<0.05$ was applied to determine whether the intervention resulted in statistically significant differences in E-PST s' DAST drawings (Chambers, 1983).

Thirty-five participants were recruited to examine the impact of a targeted intervention aimed at addressing the perceived stereotypes of scientists in an elementary education program, as measured by the standardized DAST checklist (Finson et al., 1995). Of the 33 participants, the targeted intervention elicited a decrease in scientist stereotypes in 30 participants, whereas three participants did not change their perception of scientists.

A Wilcoxon signed-rank test determined that there was a statistically significant decrease in their DAST post-intervention checklist score (Mdn =2) as compared to their DAST pre-intervention checklist score (Mdn = 7), $z = -4.805$, $p < .001$, as shown in Table 4. A point-biserial correlation was performed between the post-intervention and pre-intervention checklist scores. There was a significant negative correlation between the DAST post-intervention scores and the DAST pre-intervention scores, $r_{pb}(31) = -1.00$, $p < .001$.

Table 4

DAST Pretest and Posttest

DAST	Mean (SD)	Median	Variance	Kurtosis	Skewness
Pre-Intervention	7.0303 (1.84)	7	3.405	3.164	-.905
Post-Intervention	2.6364 (1.69)	2	2.864	1.588	1.233

Note. N = 33

As shown in Table 5, an exact McNemar's test was run to determine if there was a difference in DAST sub-category (Finson et al., 1995) drawings of scientific stereotypes, equipment/symbols, and actions/context following the targeted intervention. For the traditional scientific stereotypes, the results revealed statistically significant changes in the drawings following the targeted intervention for eccentric (Δ =-14, p<.001), lab coat (Δ = -21, p <.001), glasses (Δ =-18, p < .001), messy hair (Δ =-10, p = .021), white male scientist (Δ = -7, p < .001), and working indoors (Δ = -9, p = .035).

Table 5

DAST Sub-Categories Results

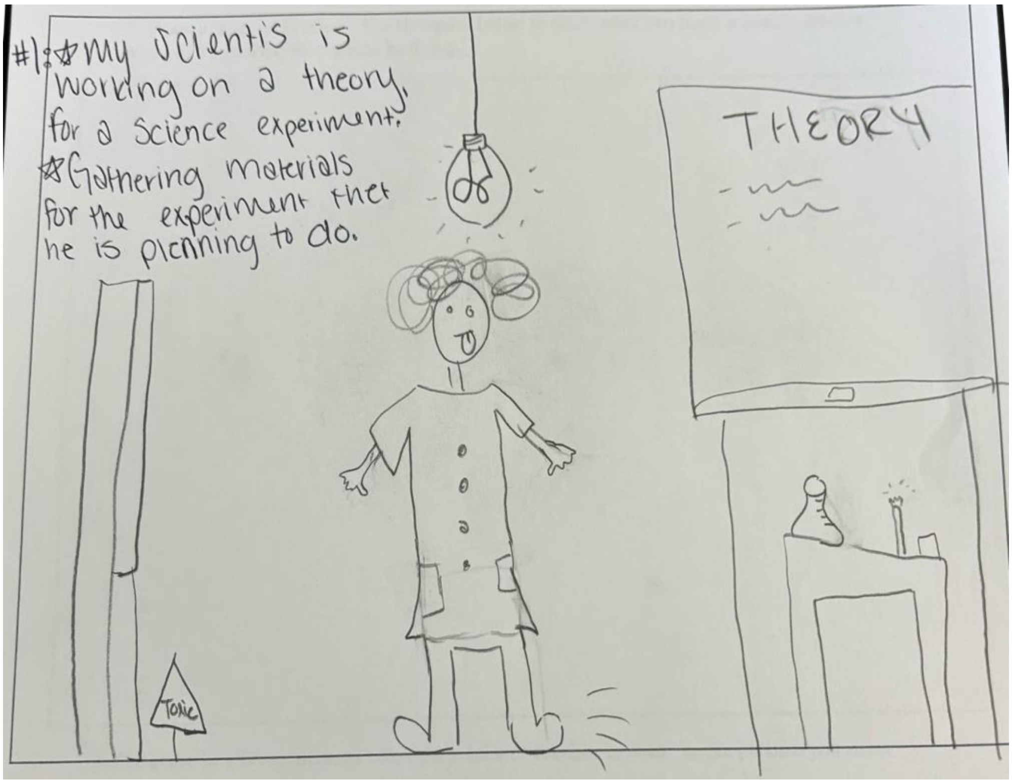
Characteristic	Indicated in Pre-Intervention Drawing	Indicated in Post-Intervention Drawing	Difference	McNemar Change Test Sig.	Rank-Biserial Correlation
Scientific Stereotypes					
Eccentric	16	2	-14	<.001*	-1.00*
Lab Coat	26	5	-21	<.001*	-1.00*
Glasses	23	5	-18	<.001*	-1.00*
Facial Hair	3	0	-3	.250	
Messy Hair	24	14	-10	.021*	-0.62*
Male	19	11	-8	.077	
Older/Aged	8	2	-6	.109	
White Male Scientist	19	2	-17	<.001*	-1.00*
Working Indoors	30	21	-9	.035*	
Equipment and Symbols					
Scientific Instruments	26	10	-16	<.001*	-0.80*
Lab Environment	30	7	-23	<.001*	-1.00*
Books/References	11	4	-7	.118	
Scientific Symbols	14	8	-6	.210	
Actions/Context					
Investigating	28	14	-14	.003*	-.70*
Data Recording	17	8	-9	.022*	-.69*
Collaborating	3	6	+3	.508	
Working Alone	30	27	-3	.453	
Dangerous Activity	7	2	-5	.180	

Note. N = 33; *Significant at p <.05

For scientific equipment and symbols, the results revealed statistically significant changes in the drawings following the targeted intervention for scientific instruments (Δ = -16, p <.001) and lab environment (Δ =-23, p < .001). For scientific context and actions, the results revealed statistically significant changes in the drawings following the targeted intervention for experimentation/investigation (Δ = -14, p = .003) and data recording (Δ = -9, p = .022). There were no statistically significant changes in the drawings for facial hair (Δ =-3), male (Δ =-8), older/aged (Δ = -6), books/references (Δ = -7), scientific symbols (Δ =-6), collaborating (Δ = 3), working alone (Δ = -3), and dangerous actions/activity (Δ = -5). As demonstrated by comparing Figure 1 to Figure 2, significant distinctions are observed between a scientist's conceptions before the intervention and those after the intervention.

Figure 1

Pre-Intervention Depiction of a Scientist

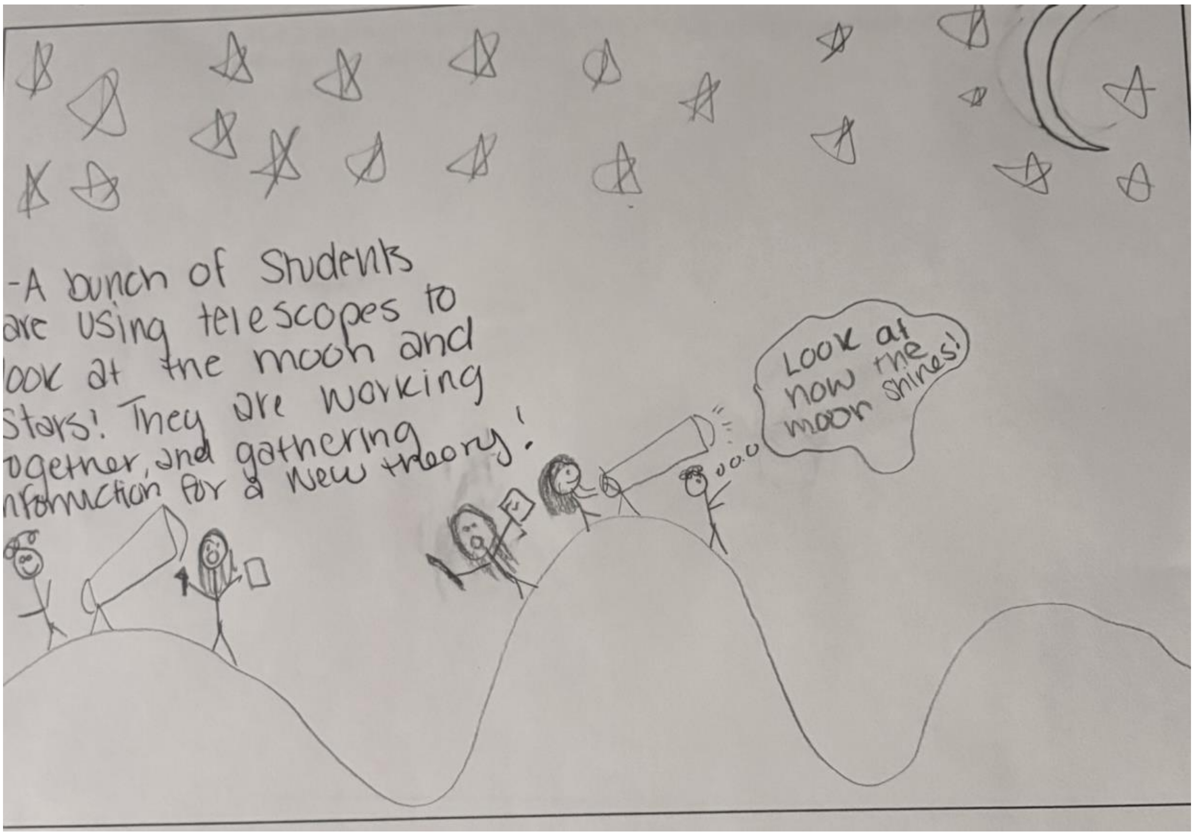


The following hypotheses were investigated for this quasi-experimental quantitative study: $\boldsymbol{H_a}$**1:** There is a statistically significant difference in the pretest and posttest DAST scores following the intervention. $\boldsymbol{H_a}$**2:** There is a statistically significant difference in the proportion of depictions of a scientist's appearance following the intervention. $\boldsymbol{H_a}$**3:** There is a statistically significant difference in the proportion of depictions of a scientist's behavior following the intervention.

This study had several important limitations, including the sample size, scope of the study, and research design. The entire sample (N = 33) was drawn from professional education courses only at a US Southeastern public university, which restricts the generalizability of the findings to larger or more diverse populations. The study assessed only short-term effects, capturing immediate changes in participants' conceptions without examining long-term retention or sustained impact over time. The study relied on only one instrument (DAST) to measure E-PST perception among scientists. The targeted intervention could have introduced response bias, as individuals could have adjusted their representations based on perceived expectations rather than genuine shifts in understanding. Finally, the absence of a control group limits the ability to isolate the effects of the intervention, as external factors influencing participant perceptions cannot be ruled out.

Figure 2

Post-Intervention Depiction of a Scientist



The data analysis revealed a statistically significant difference between the DAST pre-intervention drawing and the DAST post-intervention drawing. These results confirm previous research findings that E-PST have stereotypical conceptions of scientists (Yilmaz-Na & Sönmez, 2023), and targeted interventions can change these perceptions (Kinskey, 2023; Mbajorgu & Iloputaife, 2011).

A statistically significant change was observed in five of the nine stereotypical characteristics of scientists in the data analysis. These results indicate that further research is needed to determine if conceptual change (long and short-term) can be achieved with targeted intervention. Enrolling in more science courses that focus on non-stereotypical depictions may increase pre-service teachers' ability to teach science effectively without perpetuating further stereotyping (Avraamidou, 2013). Some research findings suggest that targeted instruction may not translate to meaningful learning (Mbajorgu & Iloputaife, 2011), while others suggest it is necessary to reduce teachers' stereotypical scientist imagery (Kinskey, 2023; Mbajorgu & Iloputaife, 2011; Škugor et al., 2020).

The data analysis revealed statistically significant changes in four of the nine scientific behaviors. While the intervention significantly altered four stereotypical depictions, some behavioral categories—such as collaborating, books/references, scientific symbols, working alone, and dangerous activities—showed changes that were not statistically significant. The DAST is not a one-size-fits-all assessment of scientific perception and misconception (Brochey-Taylor & Taylor, 2024). The changes in scientific behaviors may be attributed to limitations in the DAST instrument itself, which might be unable to capture such variations. The brief duration of the intervention (25 minutes) may not have been sufficient for all E-PST participants to change their perceptions. Future studies should consider using different instruments to measure E-PST perceptions, implementing repeated interventions, and including a larger, more diverse geographic sample size to better understand trends.

These results confirm previous research results that E-PSTs hold common beliefs that scientists conduct experimental science using stereotypical equipment and have limited exposure to other scientific endeavors (Yilmaz-Na & Sönmez, 2023). A survey comparing data from 2012 to 2018 found that only 31% of elementary teachers self-reported a strong sense of readiness to teach science effectively (Smith, 2020). While elementary teachers exhibited a general knowledge of fifth-grade scientific content; they lacked complete proficiency in elementary science content to deviate from an inaccurate curriculum (Diamond et al., 2013). Follow-up studies are essential to determine whether the conceptual changes observed in this study are maintained over time. A longitudinal research approach, which includes four periodic assessments throughout the educational program (freshman, sophomore, junior, and senior years), can provide better insights into the long-term effects of targeted interventions. These extended sessions, along with continuous support, can not only reinforce but also sustain these changes over time.

Discussions and Conclusions

The findings of this study have important implications for both educational theory and practice, indicating that brief, targeted interventions can impact elementary pre-service teachers' (E-PSTs) stereotypical perceptions of scientists. The statistically significant difference in stereotypical depictions, as evidenced by the DAST checklist scores (Finson et al., 1995), suggests that even brief interventions can have a meaningful impact on pre-service teachers' naive conceptions. The results align with previous research indicating that targeted educational strategies can effectively challenge and change entrenched stereotypes (Mbajiorgu & Iloputaife, 2011; Škugor et al., 2020). Unlike other studies that showed statistically significant differences over an entire semester (Bilir et al., 2022; Crump, 2024), statistically significant changes in stereotypical imagery were observed in one targeted intervention.

In practice, this research provides a framework for integrating stereotype-challenging interventions smoothly into educator preparation programs. Changes in sub-categories of the DAST checklist (Finson et al., 1995), such as the reduction in depictions of scientists with lab coats, glasses, and messy hair, highlight the intervention's effectiveness in addressing some specific stereotypical traits. The lack of significant change in certain categories, such as facial hair and older scientists, suggests that these stereotypes may resist change and require more intensive or repeated interventions. The results also underscore the importance of diverse representations in science education. By exposing E-PSTs to diverse and non-traditional scientists from different backgrounds and fields, the intervention helped broaden their understanding of who can be a scientist. Having this intervention before being a teacher on record is crucial for fostering an inclusive educational environment where all students can see themselves as potential scientists.

Despite the positive outcomes, the study has limitations. The small sample size and short intervention duration may limit the generalizability of the findings. Future research should explore the long-term effects of such interventions and investigate whether repeated or extended interventions yield more substantial and lasting changes in perceptions. The findings of this study corroborate previous research, suggesting that stereotypical perceptions still persist among preservice teachers (Millford & Tippett, 2012; Yilmaz & Sönmez, 2023). Despite their inconsistencies, these stereotypical images of science and scientists mainly portrayed the scientist as a loner, different from the preservice themselves, who rarely shared their pursuits with others. The primary depiction portrayed in the study aligns with prior research, which indicates a preference for white males (Christidou, 2011) with messy hair (Karaçam, 2016). As shown in Table 1, 81.8% of the participants had completed at least three science courses before participation, indicating that teaching science content alone is insufficient. Educator preparation must shift science instruction to focus on the different scientific domains, the scientists who perform these endeavors, and different modalities that engage pre-service teachers (Milford & Tippett, 2012; Škugor et al., 2020).

Some research conclusions suggest that educator preparation programs may not have the capacity to significantly change pre-service teachers' perception of science and scientists (Bezzi, 1996; Diamond et al., 2013; Mbajiorga & Iloputaife, 2001). Other research indicates that pre-service teachers have less stereotypical views than in-service teachers (Uçar et al., 2020). The findings of this study present a contrasting perspective that underscores the time required for conceptual change. When societal reinforcement perpetuates incomplete and often stereotypical conceptions, E-PSTs construct mental representations based on this inadequate information, leading to the formation of misconceptions. These misconceptions can be further compounded by their interconnections, thus perpetuating a cycle of unlearning (Gooding & Metz, 2011).

Science methods instructors are responsible for addressing these inaccuracies and assisting preservice teachers in framing science as a collaborative endeavor that transcends gender and ethnicity (Millford & Tippett, 2013). E-PSTs will need guidance, time, and space to navigate their learning cycles, and methods courses can facilitate conceptual change by promoting classroom discussions, self-assessment, and reflective thinking (Gooding & Metz, 2011) on the roles and behaviors of scientists. Teachers who possess more accurate conceptions of scientists and their behaviors are more likely to promote inclusivity in science education and instill in their students an enthusiasm for pursuing science in the future (Millford & Tippett, 2013). The key takeaway from this study is that brief, targeted interventions can lead to statistically significant changes in E-PST perceptions, highlighting their potential to address other stereotypical misconceptions.

Recommendations

Educator preparation programs should incorporate a wide range of diverse and non-stereotypical representations of scientists within their curricula. Doing so can help pre-service teachers cultivate a more inclusive understanding of the scientific profession, which they can subsequently share with their students (Škugor et al., 2020). Given the statistically significant differences observed from the 25-minute intervention (thirty participants showed a decrease in stereotypical imagery), similar interventions should be conducted regularly throughout educator preparation programs. As shown in Table 1, twenty-seven participants had taken three or more science courses, indicating a possible gap between content instruction and diverse images of scientists and their contributions. Continuous exposure to diverse representations of scientists may help reinforce and sustain positive changes in their perceptions.

Additional research is necessary to investigate the long-term effects of targeted interventions on pre-service teachers' perceptions of scientists. Longitudinal studies could provide valuable insights into how these perceptions change over time and the lasting impact of such interventions. Future interventions should specifically target the stereotypes found to be resistant to change in this study, such as those depicting older or male scientists. Tailored strategies may be essential for effectively challenging these more entrenched stereotypes. Encourage E-PST to engage in reflective practices that thoughtfully examine their perceptions and biases regarding scientists. This reflection can be facilitated through discussions, self-assessments, and journaling activities integrated into science methods courses.

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Appendix A

Close your eyes and image a scientist at work. In the space below, draw what you imagined.

1. Describe what the scientist is doing in the picture. Write at least two sentences.
2. List three words that come to mind when you think of this scientist:
    a. ______________
    b. ______________
    c. ______________
3. What kind of things do you think this scientist does on a typical day? List at least three things:

Appendix B

Draw-a-Scientist Test (DAST) Checklist

1. Lab coat (usually but not necessarily white)
2. Eyeglasses
3. Facial hair (beard, mustache, abnormally long sideburns)
4. Symbols of research (scientific instruments, lab equipment of any kind)

Types of scientific instruments / equipment.

5. Symbols of knowledge (books, filing cabinets, clipboards, pens in pockets, and so on)
6. Technology (the "products" of science)

Types of technology (televisions, telephones, missiles, computers, and so on):

7. Relevant captions (formulae, taxonomic classification, the "eureka!" syndrome)
8. Male gender only
9. Caucasian only
10. Middle-aged or elderly scientist
11. Mythic stereotypes (Frankenstein creatures, Jekyll/Hyde figures, etc.)
12. Indications of secrecy (signs or warnings that read "Private," "Keep Out," "Do Not Enter," "Go Away," "Top Secret," and so on)
13. Scientist working indoors
14. Indications of danger

Note: Several images of the same type in a single drawing count as one image (for example, two scientists eachwith eyeglasses receive only one check, not two).