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Exploring how the public "see" scientists: A systematic literature review, 1983–2024

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The public image of scientists significantly influences scientific literacy, science education, professional identity, science communication, and societal attitudes toward public issues. However, there has not been a thorough and detailed review of this topic. This paper presents a Systematic Literature Review (SLR) of 233 high-quality articles examining public perceptions of scientists. The findings indicate that studies emphasize vivid and emotionally engaging characteristics of scientists, reflecting contemporary trends, particularly during the pandemic. Research predominantly targets students across various educational levels, highlighting a gap between science education and science communication, with a reliance on quantitative methods despite the use of visualization tools. Key research limitations include a lack of humanistic perspective, issues with validity and reproducibility, insufficient cultural context analysis, weak causal inferences, and limited integration of artificial intelligence and big data, which impede advancements in science education. The paper concludes with recommendations for developing a more comprehensive conceptual framework to bridge the gaps between science education and communication, as well as their relationship with science teaching, in order to foster a positive public understanding of science.

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Introduction

Given that science, as a public enterprise and foundation of societal advancement, relies profoundly on public trust to flourish (Kossowska et al. 2021; Sonmez et al. 2023), fostering positive attitudes toward scientists has become an increasingly pressing concern within science education and communication (Leavy et al. 2023). The portrayal of scientists plays a crucial role in formal education by encouraging students to identify with scientific pursuits, with the emphasis on scientists as role models and fostering a scientific mindset being key to nurturing the next generation of scientists, promoting diversity in the scientific community, and increasing STEM enrollment (Hunter et al. 2007). Since the classic work of Mead and Metraux (1957), the depiction of scientists has been a key area of study in education, psychology, and other branches of social science (Gilpin & Wright, 1964; Leiserson, 1965). However, scientists are often depicted as intellectually ambitious yet detached and impulsive (Beardslee & O'dowd, 1961), often as malevolent mad scientists or dangerous figures (Haynes, 2003; Weingart et al. 2003), though occasionally as revered and solitary intellectuals (Ryan & Steinke, 2010).

In the contemporary era marked by an overwhelming volume of information, understanding citizens' perceptions and interactions with scientists has become a focal point in public policy discourse (Algan et al. 2021; Heyerdahl et al. 2023) and even a pivotal element in national competitive strategies. Notable examples include the "Science Integrity Act" promoted by the United States, the "Public Attitudes to Science (PAS)" conducted in the United Kingdom, and China's recent national movement of "Spirit of Chinese Scientists" (Ren, 2020). The skepticism toward scientists has politicized scientists, particularly those researching global warming and Genetically Modified Food, who are seen as elites manipulating data. With rampant online misinformation, scientists are increasingly viewed as untrustworthy, as surveys reveal a significant trust gap between scientists and the public, which has been further exacerbated by the pandemic (Jiang & Wan, 2023). During the pandemic, science and scientists faced intense scrutiny,with Sitas (2023) highlighting a pronounced decline in trust among 18- to 25-year-olds—particularly those with limited scientific education (Eichengreen et al. 2021). Additionally, there's also a noticeable decline in youth interest in scientific careers (Struyf et al. 2017), raising concerns about public apathy toward science and its social significance (Scotchmoor et al. 2009).

To facilitate a clearer understanding of academic research on public views of scientists, we drew on several studies (e.g.,Carlson et al. 2011; Pronin, 2008), using the term "see" to summarize how the public—including all individuals (excluding scientists themselves), as well as pupils and students—views and understands scientists. This approach benefits from incorporating a broad range of related concepts with varying attitudinal dimensions, such as image, view, attitude, perception, and trust. we employ a systematic literature review to explore the background and current issues in the public's perception of scientists, aiming to provide valuable insights for science education, science communication, and public policy.

Background

Public attitude toward science and science education. The public perception of scientists reflect broader attitudes towards science, scientists, and the pursuit of scientific knowledge, a trend that is garnering growing attention (Miller, 2004). Despite the conventional portrayal of science as an arena governed by rationality and universal natural principles, recent research suggests a notable shift: individuals' views of science are increasingly shaped by political ideologies, with entrenched polarization further intensifying this trend (Gauchat, 2012). This growing complexity has led to a surge in research on scientific attitudes, encompassing various dimensions such as methodological approaches, theoretical frameworks (van Aalderen-Smeets et al. 2012), and measurement instruments (Kind et al. 2007).

Additionally, several systematic literature reviews have examined this subject. Osborne et al. (2003) conducted a review of the study on scientific attitudes and their influencing factors over the past 20 years. Meanwhile, Pardo and Calvo (2002) conducted a methodological analysis of literature on the scientific attitudes of the European public. Their findings identified notable shortcomings in the content, measurement, and conceptual foundations of commonly used survey instruments. For example, simplified revisions often led to ambiguous interpretations, and questionnaire designs frequently lacked theoretical grounding. Existing measurement tools for scientific attitudes generally fall into four categories: attitudes toward science, scientific attitudes, conceptions of the nature of science, and interest in scientific careers. However, these instruments still demonstrate limitations in their psychometric robustness (Blalock et al. 2008).

Between 1998 and 2017, a group of scholars analyzed the trajectory of science education research, identifying several notable trends. From 1998 to 2002, the field was dominated by empirical studies, with a marked absence of theoretical or commentary articles. Research during this period primarily focused on students' science learning processes, examined within social, historical, and cultural contexts (Tsai & Lydia Wen, 2005). Between 2003 and 2007, attention shifted toward the participants in science education, particularly exploring the complexities of student learning, with a growing emphasis on argumentation (Lee et al. 2009). The 2008–2012 period saw an expansion of focus beyond traditional science education to include scientific inquiry and STEM education (Lin et al. 2014). Finally, from 2013 to 2017, research increasingly concentrated on issues of inequality in science education, STEM initiatives, and undergraduate research participation (Lin et al. 2019).

Perceptions of, attitude toward, and (dis)trust of scientists. Scholars have long sought to understand how individuals cognitively construct the image of scientists, including the factors that shape stereotypes and their origins. In response, targeted intervention strategies have gradually emerged—for example, the use of role models to reshape public perceptions (Corsbie-Massay & Wheatly, 2022). Research has also shown that public understanding of fundamental scientific concepts is closely linked to their attitudes toward science (Weisberg et al. 2021). Painter et al. (2006) examined students' perceptions of scientists before and after a week-long nanotechnology education program, highlighting the program's impact on student attitudes. Some scholars have proposed integrating science literacy instruction to help young children write scientific texts more effectively (Clark et al. 2021). Other interventions—such as diversifying representations of scientists in college classrooms by featuring individuals from marginalized backgrounds—have been shown to foster a greater sense of belonging in STEM fields and reduce harmful stereotypes about underrepresented scientists (Sheffield et al. 2021).

However, some traditional stereotypes of scientists' images, despite subtle shifts, have persisted for decades or even generations. Finson (2003) succinctly reviewed the literature on students' perceptions of scientists since Mead and Metraux (1957)'s seminal study, with similar findings confirmed in subsequent decades (Barman, 1999; Farland-Smith, 2009). It is widely believed that scientists are male, while other stereotypes about science and scientists vary. Recent research supports Mead and Metraux (1957)'s findings that conceptualizations of scientists vary by gender (Jones et al. 2000). Non-Caucasian students are more likely to perceive scientists as Caucasian rather than individuals of their own ethnicity (Finson, 2003; Monhardt, 2003). Over the past 30 years, Greek elementary school students have maintained common stereotypes of scientists, with the primary shift being a move from focusing on scientists' appearance to emphasizing their scientific activities (Emvalotis & Koutsianou, 2018). Similarly, the public image of scientific professions in Greece continues to retain traditional characteristics when compared to historical photographs (Christidou et al. 2019).

The multifaceted image of scientists is portrayed across various media, including movies, textbooks (Dagher & Ford, 2005), and biographies. For example, *The Big Bang Theory* draws on the stereotypical "mad scientist" trope prevalent in popular culture, yet depicts a more diverse group of scientists in terms of gender, race, and disciplines (Weitekamp, 2017). The film *Oppenheimer*, centered on J. Robert Oppenheimer—the "father of the atomic bomb"—offers a more nuanced and complex portrayal, highlighting the contradictory nature of scientists (Castelvecchi, 2023). Additionally, science fiction novels serve as a significant source shaping public perceptions, often depicting scientists as saviors of humanity across varying historical contexts and thereby continuously reshaping their image (Frayling, 2013; Haynes, 2016; Hirsch, 1958).

Gaps between public understanding of science and scientists. The authentic image of scientists is intrinsically linked to the evolution of science itself, as scientists are both products and drivers of scientific progress (Frazzetto, 2004). Some researchers, however, use the terms "public attitudes toward science" and "scientific spirit" interchangeably, a practice that has been critically challenged. While research on attitudes toward science benefits from relatively mature methodologies and theoretical frameworks, studies focusing specifically on scientists remain comparatively limited, with a notable lack of systematic reviews. Moreover, some investigations of attitudes toward science also incorporate attitudes toward scientists. Although science as an institution generally enjoys higher public trust than individual scientists, the latter serve a crucial role as intermediaries between science and society (Peters, 2013). The "Humanizing Science" initiative, originally proposed by George Sarton and supported by many scholars, emphasizes analyzing the influence of specific social and political factors on science from historical and archaeological perspectives, particularly focusing on the role of scientists within these contexts (Wylie, 2022).

Science education is not solely the responsibility of schools; direct engagement with scientists can more effectively inspire students' interest in and understanding of science. As early as 1980s, Erb et al. (1983) emphasized the importance of distinguishing between the image of scientists and the image of science when measuring educational outcomes. They argued that perceptions of scientists (i.e., individuals) are distinct from perceptions of the scientific discipline (i.e., science), noting significant differences in responses between adolescent boys and girls. The correlation patterns among perceptions of scientists, perceptions of science, and preferences for scientific careers suggest that these constructs, while related, are theoretically and empirically distinct. DeWitt et al. (2013) further noted that although positive attitudes toward science can enhance students' scientific self-concept, the image of scientists does not exert the same influence—an important distinction for science education and career guidance. Public perceptions of scientists can indeed shape attitudes toward science and influence future career choices (Hong & Lin-Siegler, 2012). Therefore, if the goal is to increase students' interest and participation in scientific careers, understanding their perceptions of scientists may be even more critical than their perceptions of science itself.

Consequently, some research and regional or international surveys have begun to distinguish between scientific attitudes and perceptions of scientists' images. For instance, Jensen et al. (2021) found that although the UK public largely disapproved of the government's pandemic response measures, scientists nevertheless retained high public regard—indeed, higher than before the crisis. This illustrates the cultural identity constraints that influence scientists' roles within national competition. In 2019, Chinese state-led media highlighted the unity and strength demonstrated by Chinese scientists when addressing national interests and adhering to universal academic norms (Zhang, 2019). This sentiment underlies the popular phrase, "Science has no borders, but scientists have their own homeland." Nadelson et al. (2014) developed the Trust in Science and Scientist Inventory specifically to measure trust in both science and scientists. However, despite recognizing the conceptual distinction between these constructs, existing measurement instruments often fail to differentiate them adequately.

To address the aforementioned gap, this study undertakes a systematic review of existing research on public perceptions of scientists, providing a comprehensive analysis of the field's research structure and quantitative characteristics. It outlines the overall framework of this area, emphasizing key focal points and recent trends. Based on this foundation, the study aims to explore the following research questions:

Q1: What are the major findings related to the perceptions of scientists? What are the overall trends in the development of the topic?

Q2: What are the existing tools for measuring attitudes towards science, and the analytical tools, etc.?

Q3: What are the limitations of current research on the topic?

Methods

The advantages of SLR lies in its rigor, transparency, clear research questions, comprehensive search strategies, explicit literature criteria, high-quality assessment methods, integrated data analysis, and reliable research outcomes (Gough et al. 2017). Therefore, we employs Systematic Literature Review (Khan et al. 2003) to conduct research and draws on previous research (Lai & Bower, 2019; Lee et al. 2021), implementing data retrieval and screening under the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Page et al. 2021).

Initial search. Guided by the principle of complementarity in research design, this study adopts both topic-based and title-based retrieval strategies to enhance the comprehensiveness and inclusiveness of the literature search (for the details, please see the Appendix 1). In the strategy one, it yielded 849 articles. Through the strategy two, a total of 17 articles were obtained. In total, combining both search strategies yielded 866 articles, providing a comprehensive and diverse array of sources for this research.

Manual screening. After conducting the initial literature search, it is common to encounter documents that appear to be relevant but are actually unrelated to the research topic. Therefore, to ensure that only literature closely related to the research topic is included in the analysis, manual screening is often necessary. This manual screening process involves two stages to efficiently and rigorously select the final literature for analysis. It also ensures

Table 1 Inclusion criteria.

Type	Inclusion criteria
Content	The core theme of the literature focuses on perceptions of scientists, including attitudes, cognition, and image.
Quality	The literature is non-duplicated.
	Papers with a length of 5 pages or more are included, while reports or short papers with less than 5 pages are excluded.
	Full-text papers are accessible.
	The literature contains comprehensive information elements, including abstracts, author information, keywords, and references.
	The literature has undergone standard double-blind peer review.

quality control over the included literature. The research team has developed the following screening criteria (see Table 1):

According to the screening criteria, we conducted two rounds of screening for the literature retrieved from Strategy One and Strategy Two. Firstly, we utilized the semi-automated systematic review software *Rayyan* to remove duplicate literature (Ouzzani et al. 2016). In this platform, preliminary screening was conducted by reading titles and abstracts, and it was determined that 414 articles from Strategy One and 847 articles from Strategy Two proceeded to the next stage. Subsequently, we performed in-depth readings of the full texts and conducted a secondary screening based on the literature selection criteria. Finally, 233 articles from Strategy One and 56 articles from Strategy Two were included as sample literature, and duplicate sample literature between the two strategies was removed. Furthermore, to further prevent the omission of key literature, based on the researchers' understanding of science education and communication, we utilized Google Scholar as a search engine (with the theme related to identity/trust of scientists) to gather additional highly relevant and highly cited literature as supplements. Ultimately, we obtained a total of 233 valid sample articles. The PRISMA process is illustrated in Fig. 1, detailing the literature screening process.

Analytical coding. After completing the manual screening, two authors conducted full-text readings of the remaining 233 articles and collected detailed information in the following five categories: literature metadata (such as publication year, article type, etc.), methodological information, and other research details of the articles.

After designing the coding scheme (for the details, please see the Appendix 2), the two authors conducted back-to-back coding to ensure the reliability of the study. After independently coding, the two authors created two separate Excel documents. By applying two commonly used methods of inter-rater reliability in educational statistics and measurement—Percent Agreement and Cohen's κ—the consistency between the two coders can be assessed (Belur et al. 2021). According to the formula for average mutual agreement and reliability calculation:

$$\text{Percent Agreement} : \mathrm{K} = \frac{\mathrm{M}}{\mathrm{N}} * 100\%;\ \text{Cohen's Kappa} : \kappa = \frac{\mathrm{K} - k_e}{1 - k_e}$$

In the above formula, M represents the number of articles on which the two coders agreed, while N refers to the total number of documents (233). K denotes the probability that both raters are measuring the same thing in a person, and k_e indicates the probability of agreement occurring by chance under ideal conditions. The results show that the K values for all coding categories exceed 90% (see Table 2), and the Cohen's κ values are greater than 0.7 (Belur et al. 2021). Therefore, the coding framework and results can be considered to demonstrate high reliability.

Results

Bibliometric analysis

Distribution of country(region) and period. A detailed analysis of publication distribution by country is presented in Fig. 2. The 233 articles included in this review originate from 40 countries. The United States leads the field with 93 publications, followed by Turkey (35), the United Kingdom (15), and Canada (9). Together, these four countries account for 152 articles, representing 65% of the total and serving as the primary drivers of research on public perceptions of scientists. In terms of publication timeline, a minor surge occurred in 1998 with six publications, followed by a relatively quiet period until 2012, when more countries began contributing to the field. Since then, the research landscape has expanded significantly. Notably, 158 articles (68% of the total) were published between January 2012 and December 2023, reflecting a period of dynamic and diversified growth in this area.

Distribution of article source. An analysis of journal distribution reveals that the 233 articles are published across 98 journals. Figure 3 highlights the top 20 journals and conferences in terms of publication volume. As shown, the majority of these outlets are concentrated in the fields of education, educational research, and science communication. Representative journals include the International Journal of Science Education, Public Understanding of Science, and Science Communication.

Distribution of authors and institutions. The results show that a significant research group focused on Jocelyn Steinke from University of Connecticut, in the field of scientist image cognition, with a total of 10 publications. Steinke's research background is in communication and STEM education. The research mainly focuses on the media portrayal of STEM professionals, adolescents' wishful identification (Steinke et al. 2012) with scientist roles on television, gender differences in science education and career participation, and the effectiveness of media interventions and role models (Steinke, 2017). In the past two years, a prominent research group led by Christidou et al. (2023) from Aristotle University of Thessaloniki introduced Emo-DAST as a novel tool for collecting and analyzing data to understand children's emotional portrayal of scientists. Researchers from some developing countries have also published relevant findings, such as Sedat Karaçam from Duzce University. Their research expertise covers various fields, including pedagogy, science and children's education, and science communication. The disciplinary backgrounds of the aforementioned researchers cover various areas, with the majority having significant contributions in the field of science communication, accounting for 33%. Following this, science education constitutes 25% of their focus, while both STEM education and children's education receive considerable attention, each comprising 17%. Other areas such as curriculum studies make up 8% of their focus.

Distribution of research object. As shown in Fig. 4, the primary focus of relevant research is on students, accounting for a significant 62%, with the majority concentrating on primary school and secondary school students. Following this are investigations from the perspectives of scientists, teachers, and the public, comprising 13%, 11%, and 11%, respectively. A small proportion of studies focus on other groups.

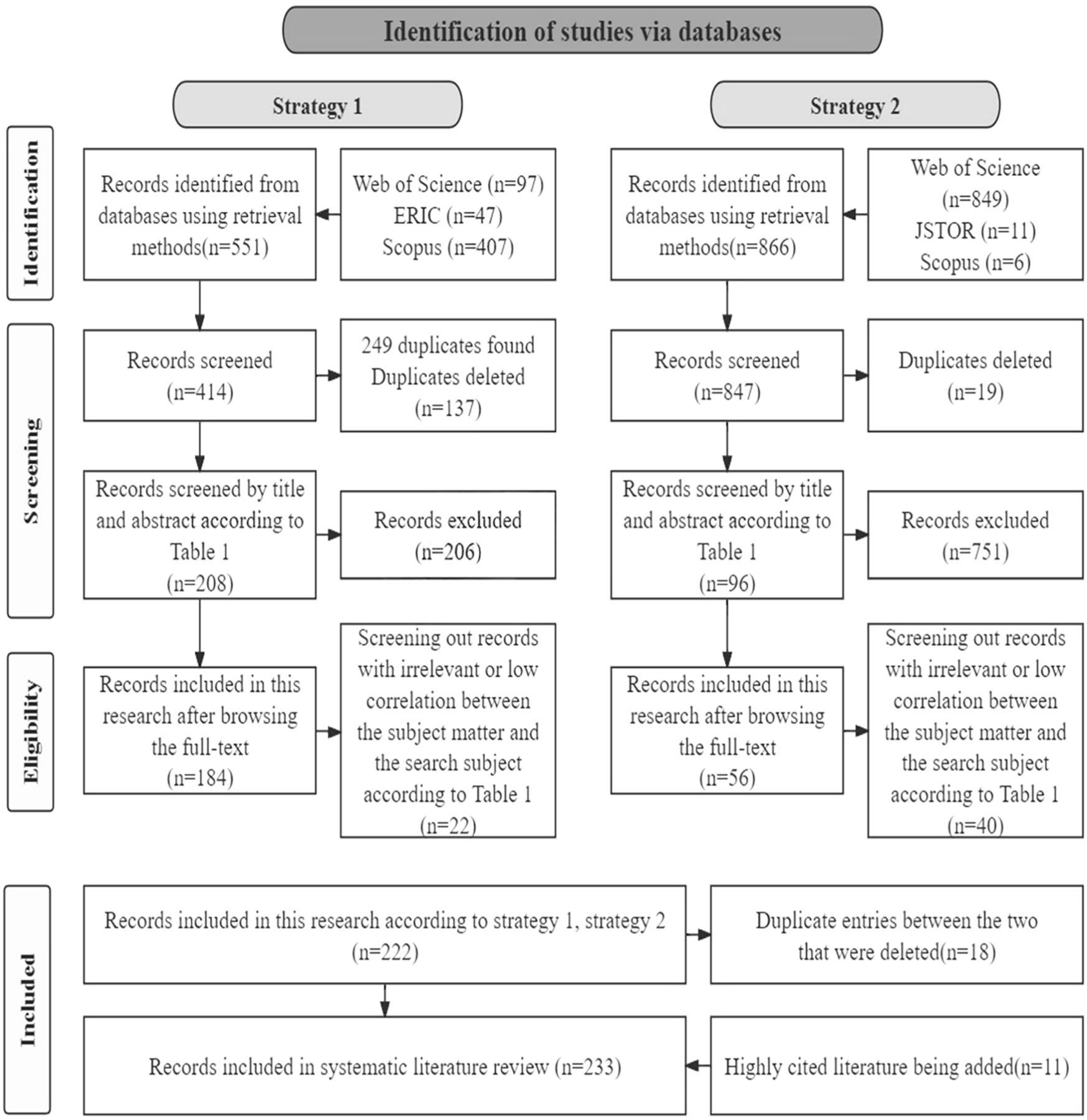

Fig. 1 PRISMA flowchart for including articles to review.

Table 2 The Inter-rater reliability of coding category.

Coding Category	% Agreement (K)	Cohen's κ
Metadata	97.72%	0.92
Research types	96.22%	0.87
Research objects	97.09%	0.90
Research topics	94.56%	0.81
Methodology	91.84%,	0.72
Limitations	95.23%	0.84

Thematic analysis

The key research topics. Using an inductive approach to thematic analysis (Braun & Clarke, 2006), which allowed themes to emerge organically from the data without imposing predefined categories, we identified four primary themes characterizing research on scientists' image: stereotypes, cognitive differences, cognitive effects, and influencing factors. The results are presented in Table 3. Literature is predominantly focused on the analysis of stereotypes of scientists ($n = 137$, 59%), with a primary emphasis on the overall image of scientists. This is followed by investigations into cognitive differences and effects regarding scientists' image cognition ($n = 55$, 24%), indicating diverse interpretations by researchers. Additionally, some studies have explored the influence of various factors on scientists' image cognition ($n = 61$, 26%).

The first theme concerns stereotype of scientists, which can be categorized into three subdomains: the overall image of scientists, the nature of their work, and their personality traits. Research consistently reveals an underrepresentation of women and culturally marginalized groups in portrayals of scientists (Mitchell & McKinnon, 2019). For example, Christidou and Kouvatas (2013) found that public perceptions of Greek scientists are dominated by the image of male physicists or chemists—often depicted with glasses, beards, and bald heads. Students frequently associate scientists with "mad" or "supernatural" characteristics (Brumovska et al. 2022). Türkmen (2008) similarly observed that scientists are commonly portrayed as older men working in eccentric laboratory settings. However, there has been a gradual shift toward more diverse representations, including scientists dressed in ordinary clothing and smiling—challenging the traditional stereotype of the bearded man in a lab coat.

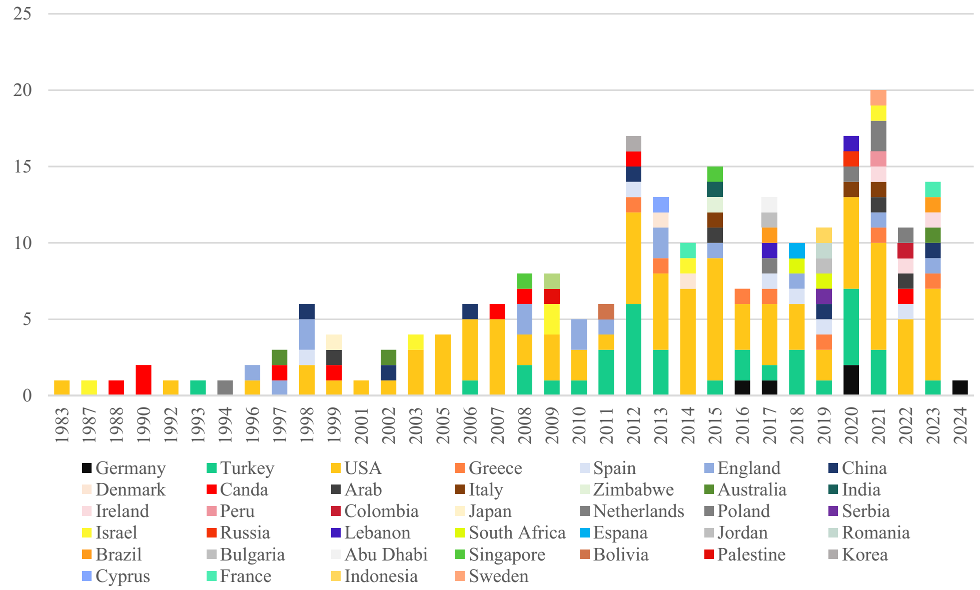

Fig. 2 Articles published in different countries(regions) in 1983–2024.

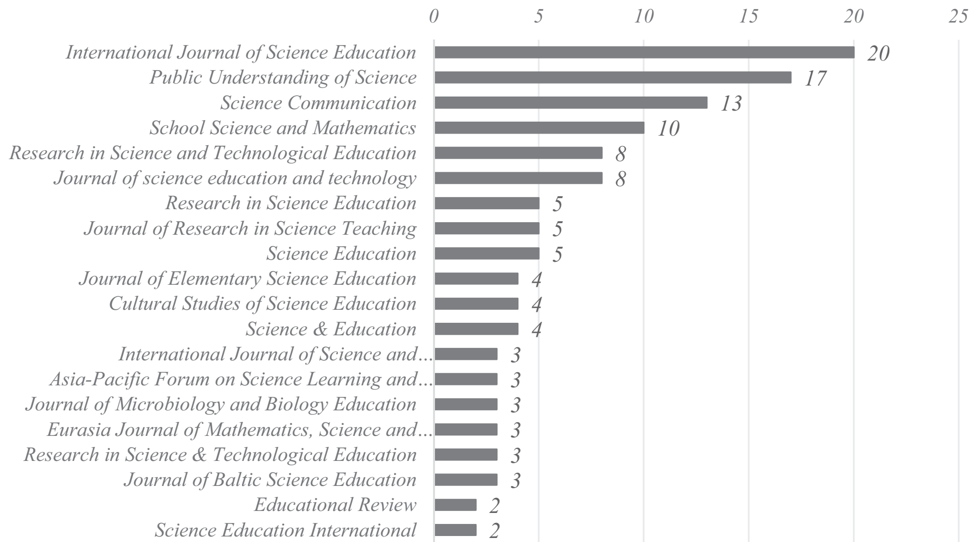

Fig. 3 Inclusion of journals with Top20 publications.

Many scholars have investigated public perceptions of the nature of scientists' work. Findings suggest that students often hold a narrow and superficial understanding, primarily shaped by intuitive experiences. Common descriptions include "doing experiments" (especially in chemistry), "conducting research," or "inventing things" (Ateş et al. 2021; Laubach et al. 2012). Two prevalent misconceptions are that scientists are obsessively devoted to research and typically work alone in laboratories (Finson, 2002).

Research on scientists' personality traits primarily investigates students' perceptions of scientists' personal characteristics. Negative stereotypes often include attributes such as aloofness, dullness, limited interpersonal engagement, and a monotonous professional life (Zahry & Besley, 2021). Subsequent studies have shown that, although stereotypical views of scientists remain pervasive, students' representations increasingly incorporate positive qualities—such as creativity and enthusiasm—as their exposure to science grows (Gormally & Inghram, 2021). McCarthy (2015) found that nearly half of the students' drawings depicted female scientists, and that portrayals of scientists' work environments extended beyond indoor laboratories; notably, over 78% of students associated scientists with smiling and happiness.

The second theme concerns cognitive differences. Students' negative perceptions of science tend to increase with age (Murphy & Beggs, 2003). In student depictions, scientists are typically portrayed as middle-aged or elderly men, with female scientists underrepresented—an age-related trend that intensifies over time (Baybars, 2020; El Takach & Yacoubian, 2020). Older students also depict scientists in more stereotypical ways (Fung, 2002; Ozel, 2012). Steinke et al. (2012) found that students identify more strongly with scientists of the same gender. Age influences students' perceptions of scientists in various respects, including the perceived age of scientists, which also varies with local economic and technological development (Losh, 2010). Furthermore, girls are often discouraged from pursuing science due to its perception as a male-dominated field. Addressing this, Jones and Hite (2022) examined K-12 students' career aspirations and views on science, calling for renewed efforts to foster trust and

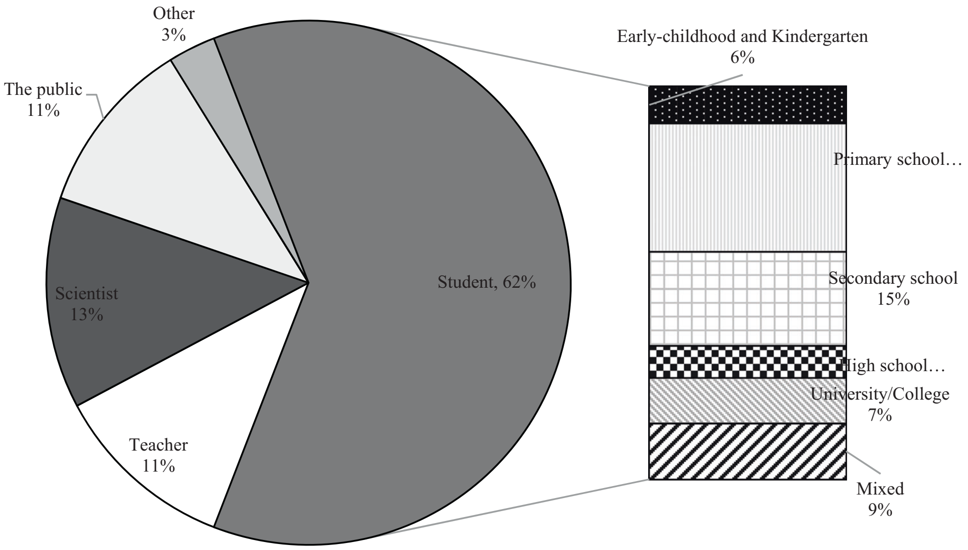

Fig. 4 Distribution of the Research Objects.

Table 3 Key Themes of Research on Public's Perception of Scientists.

Primary Level	Secondary Level	Tertiary Level
Stereotypes	Overall Image	Definition of Stereotypes
	Work Nature	Work Environment and Main Activities
	Personality Traits	Positive or Negative Traits
Cognitive Differences	Gender and Age	Gender and Age Disparities
	Race	Cultural Group
	Discipline	Different Disciplines
Cognitive Effects	Reactionary Impact	Science Education/Future Careers
Antecedent Factors	Media Medium	Media/Film/Comics /Biography
	School Education	Textbooks/School Curriculum

enthusiasm among young women toward scientific careers—an important step in addressing gender disparities in perceptions of scientists.

Cognitive differences also emerge among student groups from different racial and cultural backgrounds. Students often perceive scientists as white (Reif et al. 2020), though their representations may occasionally include scientists of other races. For instance, African American students' drawings may depict both white and non-white scientists, while Korean students frequently admire renowned Western figures such as Edison, Einstein, Newton, and Marie Curie (Sumrall, 1995). Nevertheless, minority scientists are rarely portrayed. A comparative study of American and Greek elementary students revealed a preference for young, clean-shaven scientists of European descent (Christidou et al. 2016). Watkins and Shari (2022) challenge the recurring stereotype of scientists as white males, arguing that such portrayals may discourage marginalized students from seeing themselves as future scientists. In China, students generally hold positive views of scientists, with those from economically developed regions demonstrating more favorable and nuanced perceptions of scientists' emotional traits and personal qualities (Zhang et al. 2023).

Public trust in scientists often correlates with their disciplinary backgrounds (Barman, 1999; Butler et al. 2021; O'Brien, 2013). For instance, Sonmez et al. (2023) demonstrated that natural scientists are more likely to gain public trust than social scientists. Lee (1998) showed that girls exhibit significantly lower levels of interest in science-related disciplines compared to boys, who show a greater affinity for disciplines like engineering and mathematics that are closely aligned with science.

The third theme centers on cognitive effects. Scholars argue that perceptions of scientists can influence public trust in science as well as interest in and pursuit of scientific careers. Archer et al. (2012) contend that children's stereotypical views of scientists shape their identification with and enthusiasm for science. A limited understanding of scientists' characteristics often fosters misconceptions such as "science is boring" or "only for smart people." Narayan et al. (2013) in a cross-national study, found that students who perceive science as dynamic and engaging are more likely to pursue science-related careers.

Research also highlights the positive impact of identity, particularly scientific identity, on various groups. Scientific identity is especially crucial for "quasi"-scientists—individuals aspiring to scientific careers but not yet fully established as scientists. This group notably includes postdoctoral researchers, particularly in STEM fields, who cultivate their scientific identity through intellectual work and by gaining recognition for their achievements from established scientists (Hudson et al. 2018).

The fourth theme concerns antecedent factors influencing public perceptions of scientists, with media and school education identified as primary influences. Media significantly shapes students' views of scientists, as students often derive their impressions from portrayals in advertisements, films, and comics (Tan et al. 2017). Students primarily form their perceptions of scientists from the portrayal of scientists in various media, including advertisements, movies, and comics (Kossowska et al. 2021). Negative stereotypes—such as "mad scientists" or "lab coat" characters in cartoons and TV—are commonly propagated through these channels. Downs and Smith (2010) found that males are more likely than females to regard video games as realistic sources shaping their image of scientists. Reif et al. (2020) observed that television media reporting tends to inspire greater public trust in scientists compared to emerging online video content. Seidel et al. (2020) developed a video storytelling model involving scientists in narrative production to better engage the public through media platforms. Notably, both exaggeration and understatement of scientists' images can distort reality. Egelhofer

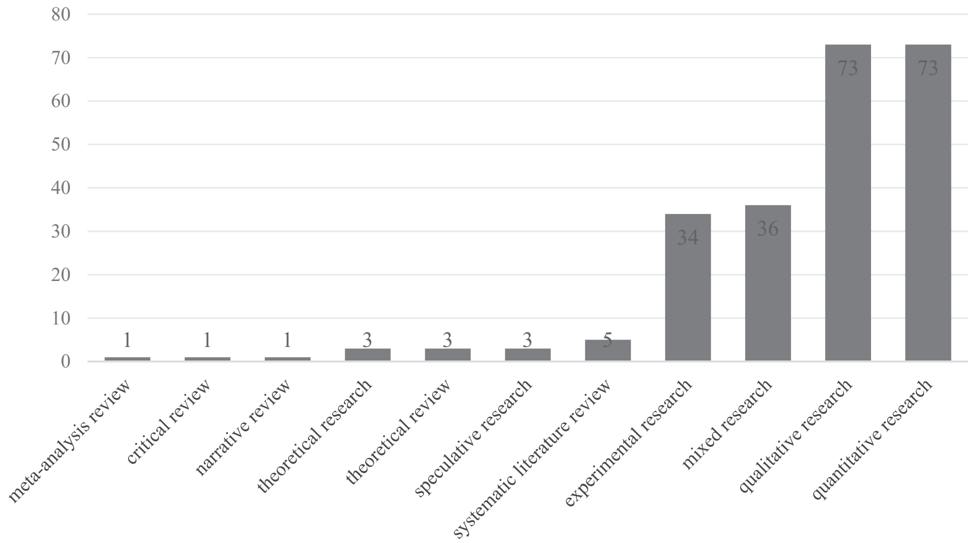

Fig. 5 Classification of research types.

(2023) highlights how politicians exploit social media to spread misinformation, deliberately creating misleading images of scientists.

In formal education, young students' scientific aspirations are strongly shaped by the science culture presented in schools (DeWitt et al. 2014). For instance, Sharkawy (2012) suggests that sharing stories of scientists from diverse social backgrounds positively influences students' cognitive and affective attitudes toward scientists. The portrayal of science in schools varies across countries, reflecting national cultures. Yacoubian et al. (2017) found that Lebanese national science textbooks predominantly depict scientists as white European males working independently as rational individuals conducting laboratory experiments.

Furthermore, teachers play a crucial role in shaping students' perceptions. Science teacher training programs can transform teachers' beliefs about science (Milford & Tippett, 2013), and these beliefs, along with teachers' views of scientists, influence their instructional methods and curriculum choices, thereby indirectly affecting students' perceptions (Ucar, 2012). Adedokun et al. (2012) highlighted disparities in the distribution of science education resources and emphasized the impact of the ZipTrips learning program. This initiative, grounded in robust pedagogical theories and interactive formats, aligns with science curricula and seeks to expand opportunities for rural high school students to engage with science and scientists.

Research methods and measurement tools. We conducted a statistical analysis of research types and found that existing studies primarily comprise meta-analytical reviews, critical and narrative reviews, theoretical and speculative studies, systematic literature reviews, experimental research, mixed methods, qualitative, and quantitative research, as illustrated in Fig. 5.

Visual tools are the most commonly used data collection method, accounting for 36.9% of studies. These include pioneering instruments such as the Draw-A-Scientist Test (DAST) developed by Chambers in 1983, the DAST-C checklist by Finson et al. (1995), the Image of Science and Scientist Scale (ISSS) introduced by Krajkovich (1978) and modified versions like the Draw-a-Science Teacher Teaching Checklist (DASTT-C) and the Modified Draw-A-Scientist Test (M-DAST). Drawing offers advantages over other measures by capturing children's perceptions before language skills fully develop (Chambers, 1983). Visual methods are especially valuable for educators addressing students' stereotypes of scientists, facilitating targeted intervention and planning. Other common methods include questionnaire surveys (32.2%), interviews or focus groups (25.8%), content analysis (13.7%), pre-post testing (8.2%), observation (5.6%), archival research (4.3%), and historical research (3.0%). Many studies also leverage existing databases to obtain large-scale samples for more robust analyses. As studies often employ multiple methods, research method categories are not mutually exclusive (see Table 4).

Table 4 The methods of data collection.

Research methods	No. of papers	%
Visual tools (DAST,DAST-C,ISSS)	86	36.9%
Questionnaire	75	32.2%
Interview focus group	60	25.8%
Content test	32	13.7%
Pre and post-test	19	8.2%
Observation	13	5.6%
Archival research	10	4.3%
Historical research	7	3.0%
Other	23	9.9%

Table 5 The methods of data analysis.

Research methods	No. of papers	%
quantitative analysis	98	42.1%
qualitative analysis	75	32.2%
qualitative & quantitative analysis	58	24.9%
Other	2	0.9%
Total	233	100%

Data analysis methods were classified into quantitative, qualitative, and mixed-method approaches, as shown in Table 5. Furthermore, quantitative and qualitative techniques were further subdivided into specific categories, detailed in Fig. 6.

Quantitative analysis primarily includes descriptive statistics ($n = 67$) and inferential methods such as regression analysis ($n = 36$) and chi-square tests ($n = 15$). Between-group difference analyses, including t-tests ($n = 22$) and analysis of variance (ANOVA) ($n = 28$), are also common, alongside less frequent methods like non-parametric tests ($n = 6$) and analysis of covariance (ANCOVA) ($n = 8$). In contrast, effect analyses—such as mediation ($n = 2$) and moderation analyses ($n = 1$)—are

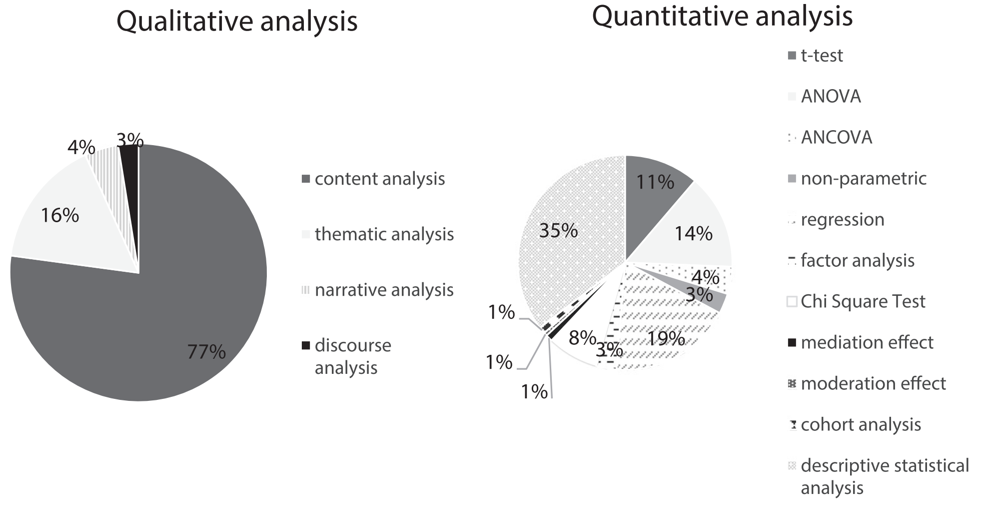

Fig. 6 Classification of statistical analysis methods.

rarely reported. This disparity suggests researchers focus more on identifying factors influencing scientists' stereotypes, group differences in perceptions, and variable relationships through relatively straightforward methods. Although effect analyses offer valuable insights, their complexity, data demands, and technical challenges limit their widespread application, leading many researchers to favor simpler, more intuitive statistical techniques to address their research questions.

In qualitative analysis, content analysis is the predominant method, employed in 91 articles (77%). Thematic analysis follows, with 19 articles (16%), primarily applied to qualitatively examine students' drawings of scientists by coding stereotypical features and analyzing accompanying narratives. Narrative analysis ($n = 5$) and discourse analysis ($n = 3$) are less commonly used. To investigate measurement approaches for scientists' images, this paper systematically reviews key tools and representative cases, summarized in Table 6.

Despite controversy (Losh et al. 2008; Reinisch et al. 2017), the Draw-A-Scientist Test (DAST) remains a prominent tool for measuring perceptions of scientists. The DAST-C improves upon the original by identifying 15 standardized stereotypical features, offering a more systematic and consistent evaluation framework that enhances comparability across studies. However, limitations persist: DAST may reinforce existing stereotypes rather than capture diverse conceptions of scientists, and cultural differences can lead to varying student perceptions across regions. Although Interobserver Agreement (IOA) methods, as applied in studies like Çavas et al. (2020), aim to improve scoring reliability, the qualitative nature of drawings renders evaluations vulnerable to subjective bias.

Four widely used questionnaires were selected for further analysis. The Student Views of Science (SVAS), developed by Ohio State University researchers, comprises five subscales including scientific method, anxiety, utility of science, and uncertainty of scientific knowledge (Ucar, 2012). The Views of Nature of Science Questionnaire (VNOS-C) features seven subscales and employs a free-response format to elicit participants' ideas and beliefs about the nature of science (Kiliç et al. 2012). The Mental Images of Scientists Questionnaire (MISQ) examines perceptions of scientists' roles, emotions, lifestyles, and work characteristics (Zhang et al. 2023). Karaçam et al. (2020) developed three preliminary scales: the Scientist Image Scale (ImSca), the Gender Perception Scale (GenSca), and the Risk Perception Scale (RiskSca).

Interviews and participant observation are commonly employed as complementary methods. O'Brien (2013) conducted face-to-face interviews exploring four dimensions: scientists' knowledge, national interest services, scientific community consensus, and policy influence. Observational methods typically assess the frequency of student–scientist interactions, students' discussion performance, and engagement, providing data to evaluate intervention effects on students' perspectives (Avraamidou, 2013). Qualitative approaches such as discourse analysis, historical research, and archival studies are also prevalent. For example, Günter et al. (2021) analyzed students' imagined identity trajectories—Straight Biology Path (SBP) and Backpacking Biology Path (BBP)—across six dimensions, including identity construction, gendered discourse, socio-cultural factors, narrative, power dynamics, and inclusivity. Review articles often examine historical documents, letters, diaries, speeches, and news reports to trace the evolution of scientists' public images and societal understanding of science.

Content testing is frequently integrated with experimental research. Houseal et al. (2014) employed quasi-experimental designs, including pre-test/post-test and non-randomized controlled group methods, utilizing multiple question formats—such as multiple-choice, short-answer, and scales—to assess the impact of the Students, Teachers, and Rangers and Research Scientists (STaRRS) program on students' scientific knowledge and attitudes. Experimental research further substantiates findings from content testing, enhancing study validity and rigor. Similarly, Adedokun et al. (2012) used content testing as a theoretical foundation and preliminary investigation for subsequent experimental evaluation of the ZipTrips program.

Table 6 summarizes commonly used instruments, each presenting distinct methodological strengths and limitations. Visual tools, such as the DAST, effectively uncover implicit stereotypes, especially among younger populations, but lack capacity to capture complex cognitive constructs. Standardized questionnaires (e.g., SVAS, VNOS-C, MISQ) facilitate broad and structured data collection, yet are susceptible to self-report biases. Qualitative methods, including interviews and discourse analyses, provide rich contextual insights but are resource-intensive and less generalizable. Observational and archival approaches contribute valuable interpretive data but are predominantly descriptive. Therefore, selection of instruments should be carefully aligned with research objectives, target populations, and underlying theoretical frameworks.

Table 6 The most frequently used tools and its exemplar case.

Types	Name of instrument	Target sample	Sub-constructs	Type of response	Exemplar studies/ original developer
Visual Data	Draw-A-Scientist-Test (DAST)	Student (College, Secondary school, Primary school, High school), Early-childhood, Teacher.	Lab coat, glasses, facial hair, symbol of research, symbol of knowledge, technology, relevant captions.	drawings	(Chambers, 1983)
	Draw a Scientist Test-Checklist (DAST-C)	Student (College, Secondary school, Primary school, High school),Early-childhood, Teacher	Lab coat, glasses, facial hair, symbol of research, symbol of knowledge, technology, Related subtitles, male, white, middle/older age, mythological figures, secrets, working in a lab, danger, smiling	drawings	(Finson et al. 1995)
Questionnaire	Students' Views About Science, (SVAS)	Student (College, Secondary school, Primary school, High school), Teacher	the scientific method (SciMet), anxiety (Anxiety), usefulness of science (Useful), and uncertainty of scientific knowledge (Uncertain)	Rating scale (Likert)	(Ucar & Sanalan, 2011)
	Views of Nature of Science (VNOS-C)	Student (College, Secondary school, Primary school, High school), Teacher	empirical, tentativeness, theory laden NOS, difference between theory and law, observation and inference, and socio-cultural embeddedness of science	Open-Ended Answers	(Kiliç et al. 2012)
	Mental Images of Scientists Questionnaire (MISQ)	Student (College, Secondary school, Primary school, High school, K-12)	Cognitive character、Affective character、Lifestyle character、Job character	Rating scale (Likert)	(Zhang et al. 2023)
	Scientist in Images Scale (ImSca)； Perception of Scientist's Gender (GenSca)；Perception of the Risks that Scientist has (RiskSca)	Student (College, Secondary school, Primary school, High school)	Risk of Being Punished by Society; Risk of Losing Health; Risk of Injury/Death; Risk of an Asocial Life; Risk of Wasted Labor; Psychological Risks	Rating scale (Likert)	(Karaçam et al. 2020)
Interview	General Social Survey (GSS)	Student (College, Secondary school, Primary school, High school), Early childhood, Teacher, The public	Perceived Knowledgeability, National Interests, Consensus, Policy Influence	Rating scale (Likert) &Binary Responses	(Hunter et al. 2007; O'Brien, 2013)
Observation		Student (College, Secondary school, Primary school, High school), Early-childhood, Teacher	Interaction with Scientists, Behavioral Engagement, Emotional Responses, Cognitive Processes, Social Interactions, Self-Expression, Reflection and Self-Assessment	performance	(Avraamidou, 2013)
Discourse	Figured World and Identities Building Tools	College student, Early-childhood	Identity Construction, Gendered Discourse, Cultural and Social Construction, Narratives and Typical Stories, Power and Influence of Discourse, Inclusivity and Diversity	Straight Biology Path (SBP), Backpacking Biology Path (BBP)	(Günter et al. 2021)
Historical/ Archival research		Scientist	Time Dimension, Cultural Dimension, Social Dimension	descriptive material	(Bucchi, 2020)
Content test		Student (Secondary school, Primary school, High school), The public	Student Perceptions of Scientists, Attitudinal Changes, Teacher Perceptions, Program Engagement, Curriculum Integration, Technical Accessibility	Rating scale	(Adedokun et al. 2012)
Experimental research	Geoscience Concept Inventory (GCI); Test of Science Related Attitudes (ToSRA); Surveys of Enacted Curriculum (SEC)	Student (College, Secondary school, Primary school, High school), Early-childhood, Teacher, The public	Test of Science Related Attitudes (ToSRA): Social Implications of Science (SIS), Normality of Scientists (NS), Attitude to Scientific Inquiry (INQ), Enjoyment of Science Lessons (ENJ), Adoption of Scientific Attitudes (AD-ATT), Leisure Interest in Science (LEI)	Rating scale	(Houseal et al. 2014)

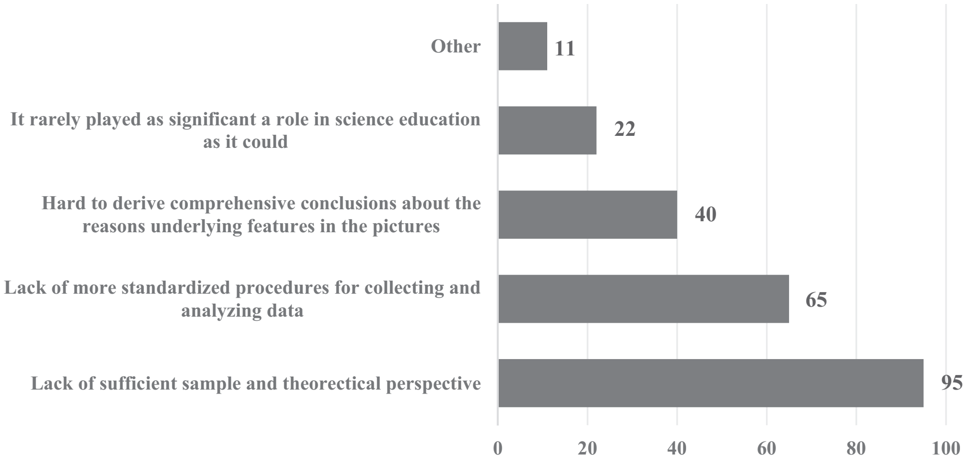

Fig. 7 Limitations of Existing Studies.

Deficiency analysis. We conducted a thorough analysis of the limitations in the 233 papers, revealing four main categories of issues. The most common issue, accounting for 40.77% (95/233) of all literature, is the "insufficient sample size and theoretical perspectives" (see Fig. 7). The designs of these studies often suffer from limitations in participant diversity, necessitating more extensive comparative analyses. Inherent scientific beliefs, religious backgrounds, or educational experiences of participants may influence research outcomes. For instance, Buldu (2006) focuses exclusively on children aged 5–8 in a public school in Turkey, potentially overlooking perspectives from broader age ranges—an issue commonly observed in studies that primarily rely on the DAST method for data collection.

Furthermore, the DAST measurement tool often leaves researchers unable to fully interpret the underlying reasons for image characteristics ($n = 40$, 17.16%), mainly due to incomplete or ambiguous student responses. In 27.89% of the reviewed literature, issues related to the lack of standardized data collection and analysis procedures were identified, including omission of key predictive features ($n = 21$), limitations of research instruments ($n = 25$), and inadequate control of confounding variables ($n = 11$). Such methodological inconsistencies undermine result comparability and reliability, while also impeding study replication and the verification of findings. Additionally, 9.44% of studies emphasize the insufficient attention given to the role of scientific image research within science education, often failing to explore its pedagogical implications or translate findings into effective teaching practices.

Discussion and conclusions

Discussion. How people "see" scientists—and the implications of such perceptions for science education and communication—is an increasingly important issue within the academic community of science education. The study conducts a comprehensive review of 233 empirical studies concerning the public perception of scientists, with a particular focus on stereotypes, cognitive disparities, influencing factors, research methodologies, measurement tools, and the achievements and limitations of the research. In contrast to investigations into attitudes toward science (Lee et al. 2021), findings from this research suggest that attitudes towards scientists exhibit greater diversity, emotions, and specificity, encompassing views, images, attitudes, trust, perceptions, stereotypes, perceptions, and identity, among other facets. Significantly, from the distribution of literature, it appears that science education is predominantly focused on instilling scientific spirit and critical thinking within formal educational institutions, while outreach efforts aimed at educating the public about science are relatively marginalized within the academic discourse. This also reflects an important issue: there is a significant gap between academic research and practical systems in science communication and science education.

In this study, we adopt the term "see" as a heuristic device to synthesize how the public forms impressions of scientists, drawing on related constructs such as perception, image, attitude, and trust. We acknowledge that these constructs emerge from distinct theoretical traditions—perception from cognitive psychology, attitude from social psychology, image from media and communication studies, and trust from sociology and risk studies—and are typically treated as analytically separate (e.g., Baybars, 2020; Christidou et al. 2023). We use the label "see" not to collapse their theoretical distinctions, but rather to offer an integrative lens through which to examine how the public—understood here primarily as the adult lay population—encounters and interprets scientists in social contexts."See", in fact, constitutes an attitudinal act, similar to "thinking about" (Besley, 2014). However, there remains a lack of comprehensive exploration into the conceptual definition and classification of public attitudes (e.g., cognitive, affective, etc.) (Besley et al. 2021; Fiske & Dupree, 2014). Practical research on the impact of various factors on perceptions of scientists' images still sidelines science education (Besley et al. 2021).

Despite growing interest in science communication and education, research explicitly focused on public perceptions of scientists remains surprisingly limited. Firstly, existing investigations into the portrayal of scientists often fixate excessively on nuances or distinctions across disparate fields (e.g., Adedokun et al. 2012; Reif et al. 2020), resulting in a dearth of an overarching theoretical or conceptual framework (van Aalderen-Smeets et al. 2012), not alone the paradigm shift. The majority of studies are confined to specific regions or disciplines, with limited cross-disciplinary dialogue or synthesis. For instance, scholars tend to scrutinize purported image disparities within rapidly emerging technologies (e.g., memes, artificial intelligence, etc.) (Fujiwara et al. 2022), thereby engendering numerous ostensibly disparate yet conceptually interconnected bodies of literature, including examinations of media depictions and televised representations, global surveys vis-à-vis specific countries or regions. Secondly, humanistic considerations regarding the portrayal of scientists and science education remain notably inadequate (Clough, 2011; Kruse & Borzo, 2010). As articulated by Sarton (1924) at the outset of this discourse, the absence of humanism remains a pressing concern. Particularly given the pervasive influence of political ideologies and authoritarian regimes on science and scientists (Wang, 2002), researchers ought to attend to how the scientific community, society, and governments shape the public perception of science and scientists. Finally, research on the image of scientists seems inherently disconnected from how to advance science teaching, especially those studies that focus solely on public perceptions and attitudes towards scientists. Some research on the image, attitudes, and cognition of scientists reduces the scientist's image to a mere dependent variable—treating it as an end rather than a means—and thereby overlooks its potential mediating role in enhancing public understanding of science.

Conclusions. For research on the image of scientists, it is necessary to explore the following aspects in depth. (1) Future research should adopt a more diverse theoretical framework that integrates interdisciplinary perspectives and the epistemology of science while broadening the analytical scope of existing research on the portrayal of scientists to incorporate critical examinations of discursive texts, social phenomena, and the associated disparities and politicization. (2) It should aim for a comprehensive approach or concept to effectively combine science education and science communication. In many ways, science education and science communication have similar objectives. Both aim to educate, entertain, and engage the public with science. However, it's somewhat surprising that, despite these shared goals, they have developed into separate academic fields that often overlook one another (Baram-Tsabari & Osborne, 2015). It is imperative not only to elucidate the public's perceptions of scientists but also to explore how scientists perceive the public and discern differences therein. (3) Future studies should expand the use of experimental methodologies in science education, while cautiously adopting traditional and new research methods (Losh et al. 2008; Reinisch et al. 2017). Longitudinal study and neuroimaging can track intervention effects and reveal the neural basis of students' attitudes toward science. Causal inference methods can also clarify factors influencing students' interest in science learning and careers. (4) Future researchers should take seriously the distinctions between studies on attitudes toward science and those toward scientists (Cologna, 2025). It is also imperative to rigorously differentiate among various forms of public attitudes—such as attitude, perception, view, opinion, and trust—while clarifying their respective theoretical and practical implications. Building upon these typological distinctions, scholars are encouraged to develop a more integrative and universally applicable analytical framework or theoretical model.

To promote the linkage between images of scientists and science education, we offer two preliminary suggestions for the development and implementation of public perceptions of scientists in formal or informal education: (1) Contextualizing scientist image education within local cultures and values. To enhance its relevance and inclusivity, scientist image education should adapt to diverse sociocultural and ideological contexts. This may include emphasizing emotional education, civic responsibility, and national identity (e.g., national security education), while exploring the cultural heritage, moral character, and civic contributions of scientists (Ren, 2020; Zhang, 2019). A balance should be maintained to avoid politicization or essentialism. (2) Clarifying the positioning and pedagogical use of scientists. Educators should critically examine the roles scientists play in curricula, avoiding uncritical hero-worship, scientism, or the fetishization of science (Allchin, 2003). Guidelines should be established to prevent overreliance on authority and to determine whether the instructional goal is to foster deeper understanding of science, develop critical thinking, or achieve broader educational values.

This systematic literature review also has some limitations that should be acknowledged. On one hand, this study is limited to English-language publications, which means that practices or research related to the spirit or image of scientists in non-native English-speaking countries or regions that may also be advanced in science education and science communication (e.g., Turkey, Japan, Russia) may have been overlooked. Future research should pay attention to non-English-speaking countries or regions. An additional limitation of the study is its failure to examine scientists' perspectives on the public, science education, and science communication. These factors are crucial as they influence research and practices in these areas, a point supported by (Taylor et al. 2008). To address this, future research could conduct a systematic literature review to explore this supplementary perspective

Data availability

No datasets were generated or analysed during the current study.

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