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Junior High School Science Teachers' Perceptions of Scientists: A Survey & Critical Analysis

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Abstract— *Scientists play a crucial role in the advancement of science and technology; however, public perceptions of them are still influenced by various stereotypes and limited understanding. Science teachers, as educators who shape students' perceptions of scientists, hold views that can influence how science is taught and understood in schools. This study aims to analyze science teachers' perceptions of scientists, covering aspects such as the image of scientists, trust in the scientific method, scientists' relationship with society and education, their relevance to religious and cultural values, and the attractiveness of the scientist profession. The study employed a survey method involving 61 science teachers from various schools in Indonesia. The findings indicate that while most respondents have high confidence in scientists and the scientific method, there remains a gap in the representation of contemporary scientists in education and media. Additionally, scientists are still perceived as having limited involvement in formal education and public communication. Although the scientist profession is regarded as appealing, challenges such as gender stereotypes and the exclusivity of science continue to be barriers. Therefore, more inclusive strategies in science education and communication are needed to strengthen the role of scientists in society.*

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Introduction

Natural Science scientists play a crucial role in the advancement of science and technology, which directly impacts various aspects of human life [1]. Their contributions are evident in major discoveries such as Einstein's theory of relativity, Newton's laws of motion, and Edison's electrical innovations, as well as in the development of modern technologies like artificial intelligence, biotechnology, and space exploration [2]. Despite their critical role, public perception of scientists remains influenced by stereotypes and limited understanding [3]. In the field of education, science teachers hold a strategic position in shaping students' views of scientists and the scientific world [4]. They do not merely deliver scientific content but also play a role in instilling the image of scientists as individuals who contribute to the advancement of civilization [5]. However, how science teachers themselves perceive scientists remains an intriguing question for research, particularly in the context of representation, relevance to society, and the relationship between science and cultural and religious values.

Previous studies indicate that the image of scientists is often shaped by stereotypes perpetuated in media and formal education [6]. Many students describe scientists as elderly men wearing lab coats, with disheveled hair, working in laboratories filled with chemicals [4]. This representation suggests that scientists are frequently perceived as eccentric figures isolated from society [3]. Furthermore, other studies reveal that scientists are more commonly associated with technological innovation rather than their social and educational roles [7]. Such stereotypes can influence young generations' perceptions of the scientific profession, ultimately affecting their interest in pursuing careers in science [5].

Trust in the scientific method is also a crucial factor in understanding how science teachers perceive scientists [7]. Science progresses through evidence-based methods and continuous revision based on new findings [6]. However, many people still view science as absolute and unchanging [3]. If science teachers fail to grasp the dynamic nature of science, this may impact how they teach science in the classroom and potentially lead to misconceptions among students regarding how scientific knowledge evolves [5].

Additionally, the relationship between scientists and society, as well as education, remains an area requiring further exploration [3]. Although scientists are acknowledged as drivers of innovation, they are often perceived as being distant from everyday life and

having limited involvement in formal education [7]. Fensham (2004) found that scientists rarely engage directly in elementary and secondary education, leading students to learn about them solely through textbooks without truly understanding how scientific knowledge is applied in real life [6]. This lack of interaction reinforces the perception of scientists as exclusive figures with limited relevance to social and educational contexts.

Another important aspect to examine is how science teachers perceive the relationship between scientists and religious and cultural values. Science is often associated with rationality and secularism, leading to the perception in some contexts that scientists are less religious [6]. Science teachers' perceptions of the connection between science and religion are crucial, as they play a role in conveying science to students who may have strong religious backgrounds. If the relationship between science and religion is not adequately explained, it could lead to misunderstandings that hinder students' acceptance of scientific knowledge [7].

The appeal of the scientific profession is another aspect that needs to be investigated in this study. Although scientists play a significant role in technological and scientific development, interest in this profession is not always high [6]. The OECD (2018) reported that in several countries, students' interest in becoming scientists has declined due to the perception that this profession is less financially rewarding compared to fields such as business or technology. Moreover, the common portrayal of scientists as individuals engaged in complex laboratory work requiring high levels of dedication may make the profession less attractive to most students. Thus, examining how science teachers perceive the appeal of a scientific career and whether they play a role in inspiring students to pursue careers in science is a relevant question for this study.

Despite numerous studies on public perceptions of scientists, research specifically investigating how science teachers perceive scientists remains limited. Most prior research has focused on students' or the general public's perceptions, without considering how teachers, who have a central role in science education, shape and disseminate the image of scientists to younger generations. Additionally, previous studies have rarely explored how science teachers perceive the relevance of scientists in education and society or how they evaluate the relationship between science and religious and cultural values. This research gap highlights the need for further studies on how science teachers conceptualize the role of scientists in various aspects, including scientific progress, social interaction, and the appeal of the scientific profession.

Based on this background, this study aims to analyze how science teachers perceive the image of scientists, including stereotypes related to gender, age, and profession. Furthermore, this study seeks to identify the level of science teachers' trust in scientific knowledge and methods, as well as their understanding of the dynamic nature of science. This research also explores science teachers' perceptions of scientists' relationships with society and education, and the extent to which they consider scientists as relevant figures in the educational domain. Additionally, the study examines how science teachers perceive the intersection between scientists and religious and cultural values in education, as well as their evaluation of the appeal of scientific professions and scientists' roles in addressing contemporary challenges, particularly in technological advancements and global changes. By understanding how science teachers view scientists, this research aims to provide deeper insights into how the image of scientists is constructed within education and how educational approaches can be improved to increase students' interest in science and scientific careers in the future.

Method

This study employs a survey method to explore science teachers' perceptions of scientists in the field of Natural Sciences. The survey involves 61 respondents, comprising science teachers teaching at various educational levels, including junior high schools (SMP), Islamic junior high schools (MTs), and senior high schools (SMA) across different regions in Indonesia. The respondents were selected through purposive sampling based on the criterion that they were actively teaching science subjects, ensuring they could provide relevant insights into the image of scientists and their relationship with education and society.

Data were collected through a questionnaire consisting of several sections, including respondents' demographic characteristics, teaching experience, and opinions on various aspects related to scientists in the field of Natural Sciences. The demographic characteristics examined included gender, age, highest educational attainment, school location, certification status, grade levels taught, and teaching experience. Among the total respondents, the majority were female, with educational backgrounds ranging from bachelor's (S1) to master's (S2) degrees, and teaching experience varying from less than five years to more than 15 years.

The questionnaire employed a Likert scale to measure respondents' levels of agreement regarding various aspects of scientists' perceptions, such as their image, trust in scientific knowledge and the scientific method, scientists' relationship with society and education, and the appeal of the scientific profession in contemporary times. The collected data were analyzed quantitatively by examining the percentage distribution of responses for each statement. This analysis aims to identify general patterns in science teachers' perceptions of scientists and explore potential factors influencing these perceptions.

Result and Discussion

The Image of Natural Science Scientists

The majority of respondents (83.6%) strongly agree that scientists such as Einstein, Newton, Edison, and Curie have made significant contributions to scientific knowledge, indicating that classical figures still dominate the public perception of Scientists. This dominance suggests that education and media continue to highlight historical figures, while contemporary scientists receive comparatively less exposure. Consequently, the public may be less aware of the roles that modern scientists play in technological advancements and scientific innovations [8][9][10].

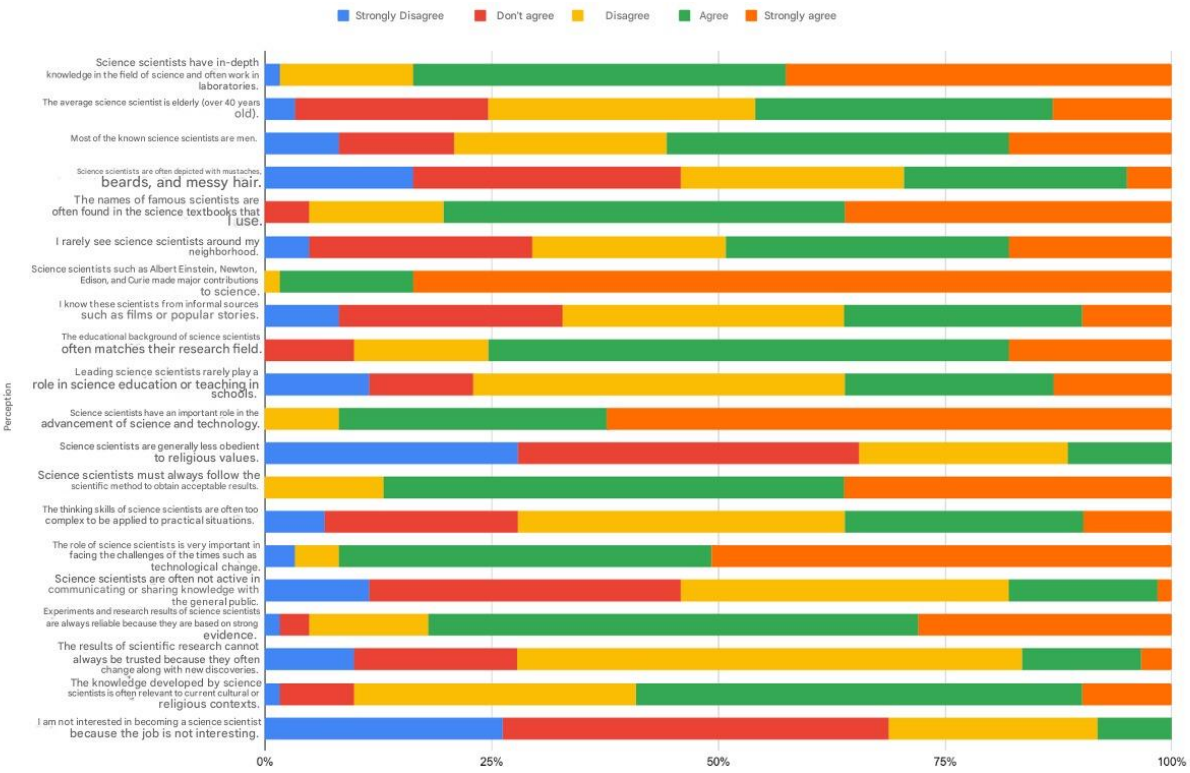

Fig. 1. Science Teachers' Perceptions of Scientists

Additionally, Scientists are generally perceived as possessing deep expertise in their respective fields, with 83.6% of respondents agreeing or strongly agreeing with this statement. While this perception is positive, it may also reinforce the notion that the scientific community is an exclusive environment accessible only to individuals with exceptionally high intelligence [11]. If this perception becomes too dominant, it may create psychological barriers for young people interested in pursuing careers in science, as they might feel they are not "smart enough" to become scientists [12]. Therefore, a more inclusive educational approach is needed to emphasize that the scientific world is open to anyone with curiosity and a willingness to learn.

Although Scientists are respected for their expertise, certain stereotypes remain attached to their image. A total of 29.5% of respondents agreed or strongly agreed that Scientists are often depicted with mustaches, beards, and disheveled hair. While the majority of respondents do not fully support this stereotype, the fact that nearly one-third still hold this view suggests that media and popular culture continue to reinforce the eccentric and untidy image of scientists. This stereotype risks creating a divide between the public and the scientific community, as scientists may be perceived as fundamentally different from ordinary people rather than as relatable and relevant figures in everyday life [13].

Furthermore, gender bias remains significant in public perceptions of Scientists. A total of 55.7% of respondents stated that the scientists they were most familiar with were predominantly male. This reflects the historical reality of male dominance in science but also highlights the lack of visibility of female scientists who have made significant contributions across various scientific disciplines [14]. The underrepresentation of women in science may influence young girls' aspirations, making them feel that they have limited opportunities in the field. To address this, greater efforts are needed to feature female scientists in educational curricula, media, and inspirational programs to reduce this perception gap [15].

Perceptions regarding the age of scientists also contribute to their public image. A total of 45.9% of respondents agreed or strongly agreed that the average Scientist is over 40 years old. This view may arise because many well-known scientists achieve recognition only after years of research. However, if this perception persists, it may create the belief that science is a field relevant only to older individuals, ultimately diminishing the appeal of a scientific career for younger generations [16]. In reality, many modern scientific innovations are spearheaded by young scientists, particularly in technology and biotechnology. Therefore, it is essential to highlight young scientists actively contributing to the field to create a more balanced perception.

Lastly, the majority of respondents (75.4%) stated that the educational background of Scientists often aligns with their research fields. This suggests that the public recognizes the importance of relevant education in scientific careers. However, in practice, many scientists work in fields that do not strictly match their initial academic backgrounds, particularly with the growing prominence of interdisciplinary research. For instance, computer scientists contribute to biotechnology, while physicists play critical roles in medical research. If the public perception remains fixed on the strict alignment between educational background and research focus, it may hinder flexibility in the scientific field, where multidisciplinary skills are increasingly necessary for solving complex problems.

Overall, the image of Scientists in society is still influenced by classical representations that acknowledge their contributions while simultaneously maintaining various stereotypes related to gender, age, and appearance. While scientists are perceived as highly knowledgeable individuals, the notion of exclusivity and limited representation may discourage younger generations from

pursuing careers in science. Therefore, systematic efforts from the education sector, media, and the scientific community are needed to introduce a more inclusive image of scientists—encompassing diverse gender identities, age groups, and backgrounds—so that the scientific world becomes more open and appealing to all members of society.

Trust in Science and the Scientific Method

Public trust in science and the scientific method exhibits a generally positive trend, with the majority of respondents (86.9%) believing that Scientists must always adhere to the scientific method to obtain acceptable results. This reflects a strong understanding of the importance of systematic procedures in scientific research, indicating that society still holds high confidence in the validity and objectivity of the scientific method [17] [18]. This trust is particularly crucial in today's information era, where misinformation and pseudoscience spread rapidly, especially through social media [19]. Research indicates that individuals with a solid grasp of the scientific method are generally more capable of distinguishing between valid and unreliable information [20].

Support for science is further reinforced by the fact that 82% of respondents believe that the findings of Scientists can be trusted because they are based on strong empirical evidence. This suggests that the public acknowledges the importance of empirical data in constructing reliable knowledge [21]. However, despite relatively high trust in scientific research, challenges remain in public understanding of the dynamic nature of science. A total of 55.7% of respondents expressed disagreement with the statement that research findings can change with new discoveries, indicating a misunderstanding of the evolutionary nature of scientific knowledge [22]. Studies have shown that a lack of understanding of this concept can lead to confusion regarding the processes of revision and falsification in science [23].

Scientific advancements are often perceived as inconsistencies or even failures, whereas, in reality, scientific progress relies on continuous refinement. For instance, in the medical field, perspectives on diseases or treatment methods frequently change as new, more accurate data emerge [24]. A lack of awareness of this process can make the public more vulnerable to unhealthy skepticism, ultimately diminishing trust in science, particularly during crises such as pandemics or climate change [25].

On one hand, strong public trust in the scientific method is beneficial, as it signifies acceptance of scientific authority in evidence-based decision-making. On the other hand, if this trust becomes absolute without a critical understanding of the dynamic nature of science, it can foster a dogmatic perspective [26]. Scientific findings should neither be accepted unquestioningly nor dismissed outright simply because alternative perspectives exist. Therefore, improving scientific literacy is essential in helping the public understand that changes in science do not signify uncertainty but rather demonstrate the robustness of the scientific method in pursuing more accurate truths [27][28].

Public trust in science and the scientific method remains relatively strong; however, there is a gap in understanding the flexible nature of scientific research. Science is not a static doctrine but a continuously evolving system of knowledge that undergoes constant testing and revision. Therefore, it is essential for science education and communication to not only emphasize the reliability of the scientific method but also explain how science progresses. By doing so, society can better appreciate that changes in scientific knowledge are not a sign of uncertainty but rather evidence of the resilience of the scientific method in refining our understanding of reality.

The Relationship Between Scientists, Society, and Education

The relationship between Scientists and society, particularly within the educational sector, still exhibits a significant gap. Although the majority of respondents (80.3%) agree that Science textbooks include the names of many well-known scientists, this does not necessarily foster a sense of closeness between scientists and the general public. The mention of scientists in textbooks is often historical and does not always relate to their contributions in everyday life. As a result, scientists continue to be perceived as distant figures rather than as individuals actively contributing to the modern world. Research suggests that to enhance public engagement with science, education should integrate scientific concepts with daily experiences and social relevance [29].

This gap becomes even more apparent from data indicating that nearly half of the respondents (49.2%) rarely see Scientists in their surroundings. This perception suggests that scientists lack sufficient visibility in public spaces, whether through direct engagement or media representation. In reality, scientists should not only operate within laboratories or academic institutions but also play a role in communicating scientific knowledge to the broader community [30]. If the public perceives scientists as inaccessible, this could further widen the gap between science and society, potentially increasing distrust in science, particularly on controversial issues such as climate change or vaccine technology [31].

In the field of education, the role of Scientists is also seen as limited. A total of 36% of respondents agree or strongly agree that Scientists rarely contribute to school education, while 41% express disagreement. This data suggests that public perceptions regarding the involvement of scientists in education remain divided, possibly due to the more dominant presence of scientists in higher education institutions rather than in primary or secondary schools [32]. However, the presence of scientists in primary and secondary education is crucial for fostering students' early interest in science. If Scientists collaborate more frequently with teachers to deliver lessons or share firsthand experiences, this could enhance students' appreciation for the scientific field and encourage them to consider careers in science [33].

Perceptions of Scientists' engagement in sharing knowledge with society also vary significantly. A total of 36.1% of respondents disagree with the statement that scientists are inactive in public knowledge dissemination, while 18% agree or strongly agree. This suggests that while some scientists are actively involved in public communication, these efforts remain inconsistent or are not widely recognized by the general public. Scientific communication should not be confined to academic journals or conferences that are accessible only to specialized audiences but should also be presented in more engaging and easily understood formats, such as through social media, documentaries, or community outreach programs [34].

However, a positive aspect of the relationship between scientists and society can be seen in the perceived relevance of scientific knowledge to cultural and religious contexts. A total of 59.1% of respondents agree or strongly agree that the scientific knowledge developed by Scientists is relevant to contemporary cultural and religious values. This indicates that although debates persist in certain regions regarding conflicts between science and religion, the majority of society still perceives science as adaptable and compatible with existing cultural and spiritual values [35].

The relationship between Scientists and society, particularly in education, still faces numerous challenges that need to be addressed. Scientists are still largely perceived as distant figures with limited involvement in daily life, both in communities and in the education sector. To overcome this, more effective strategies are required to enhance scientists' visibility in public spaces, whether through greater engagement in school education, broader scientific communication, or active participation in social discourse. Strengthening these connections will not only increase public appreciation for scientists but will also enable them to play a greater role in fostering a society that is more aware of the importance of scientific knowledge in everyday life.

Scientists and Religion

The relationship between Scientists and religion has often been a subject of debate, particularly due to the historical tensions between science and religious beliefs throughout certain periods. However, data indicate that the majority of respondents (65.5%) disagree with the notion that Scientists are less adherent to religious values, while only 11.5% agree. This suggests that in public perception, Scientists are not necessarily associated with a detachment from religion, and the view that science conflicts with spiritual values is diminishing [36][37]. These findings are particularly interesting as they reflect a paradigm shift in which science and religion are increasingly seen as two entities that can coexist rather than being in absolute opposition. While history records several conflicts between science and religion—such as the cases of Galileo Galilei and Darwin's theory of evolution—modern thought has evolved to show that many scientists hold religious beliefs and view science as a means to understand the order of the universe [38][39]. The fact that the majority of respondents reject the stereotype that scientists are less religious indicates an increasing inclusivity in public understanding regarding the diversity of perspectives within the scientific community.

However, 11.5% of respondents still associate Scientists with a lack of adherence to religious values. This figure may reflect the perception that science is often based on rationality and empirical evidence, which in some cases can be at odds with faith-based or traditional beliefs [40]. Some individuals may view scientists as prioritizing logic over spiritual conviction, leading to misunderstandings that scientists lack religious affiliation. Additionally, in certain social contexts, science is frequently associated with secularism, especially in discussions related to topics such as the origins of the universe, bioethics, or genetic technology [36][41].

On the other hand, although the majority of society does not perceive Scientists as less religious, this does not necessarily indicate a deep understanding of how scientists view the relationship between science and spirituality. Many scientists continue to practice their faith while maintaining a strong commitment to the scientific method. Some even argue that science reinforces their belief in the vastness of the universe and the complexity of natural laws [37][39]. This demonstrates that the dichotomy between religion and science often discussed in public discourse does not always reflect the reality within the scientific community itself. Research suggests that integrating science and religion can lead to a more holistic understanding of the world and human existence within it [38][41].

The data suggest that society is becoming increasingly open to the idea that Scientists do not necessarily abandon religious values in their profession. Science and religion do not have to be in constant conflict; rather, they can complement each other in understanding life and the universe. However, a small segment of society still perceives scientists as more secular, indicating that the dialogue between science and religion needs to be further strengthened to eliminate lingering misconceptions. By enhancing this understanding, society can better appreciate scientists not only as seekers of scientific truth but also as individuals who embody diverse beliefs and spiritual values.

Scientists and the Appeal of the Profession

The profession of Scientists remains highly appealing in the eyes of the public, as evidenced by the majority of respondents (68.8%) who disagreed with the statement that being an Scientist is not an attractive career. This indicates that careers in science are still valued and considered essential to society, whether in terms of innovation, knowledge exploration, or contributions to technological advancements. Research suggests that positive perceptions of scientists may be influenced by the increasing visibility of scientific progress in daily life, rapid technological development, and greater media exposure of scientists, including on social media platforms [42][43]. This reflects a growing public awareness of the role of science in addressing global challenges such as climate change and public health issues [44].

However, despite the majority viewing the profession as attractive, approximately 8.2% of respondents still find it unappealing. While this number is relatively small, it remains relevant for further analysis. Negative perceptions of the Scientist profession may stem from stereotypes portraying scientific work as monotonous, heavily theoretical, and lacking immediate gratification. Studies indicate that the perception of scientists as individuals engaged in lengthy laboratory research requiring high levels of dedication may discourage younger generations from pursuing careers in science [45][43]. Additionally, the challenge in attracting young talent to the profession is also linked to how it is perceived within broader social and cultural contexts [46].

The appeal of the Scientist profession is also significantly influenced by social and economic factors. In some contexts, scientific careers may not offer financial prospects comparable to fields such as technology or business. If career opportunities and rewards for scientists are insufficient, this could reduce young people's motivation to pursue the profession [47][43]. Therefore, it is crucial for governments, academic institutions, and industries to ensure that scientists receive proper recognition, whether through financial incentives, research opportunities, or broader social acknowledgment [48].

Moreover, science communication plays a vital role in enhancing the appeal of the scientific profession. If Scientists actively engage in sharing knowledge in engaging and relatable ways—such as through social media, public seminars, or scientific projects with direct societal impact—the profession could be seen as more dynamic and influential [49][43]. Currently, some scientists have successfully popularized science through digital platforms, increasing the profession's appeal to younger generations [50]. Thus, effective science communication is essential in reshaping public perceptions of scientific careers.

Although the Scientist profession remains attractive to most of the public, challenges persist in enhancing its appeal, particularly regarding perceptions of scientific work as overly serious and time-consuming. To ensure that more individuals are drawn to becoming scientists, academia, government, and media must continue to promote this profession not only as intellectually valuable but also as a career path with tangible impacts on human life [51][43]. By increasing public exposure to the contributions of scientists in everyday life and creating a more supportive ecosystem for scientific careers, the profession can become increasingly appealing to future generations.

Scientists in the Evolution of Time

The presence of Scientists in the evolution of time is widely recognized as a key factor in the advancement of science and technology. This is reflected in the high percentage of respondents (91.8%) who agreed or strongly agreed that Scientists play a crucial role in driving innovation and discoveries. The strong trust in scientists suggests that society acknowledges their contributions across various fields, including health, energy, the environment, and artificial intelligence. Research indicates that effective communication between scientists and the public can enhance public understanding of science and technology, as well as encourage the application of research findings in everyday life [52][53]. However, despite the significant appreciation for scientists, the primary challenge lies in ensuring that their research findings can be widely applied and provide tangible benefits to society. This includes addressing the gap between scientific research and public policy, which often fails to align with scientific recommendations [54].

In addition to contributing to scientific progress, Scientists are also perceived as central figures in addressing contemporary challenges, particularly in navigating technological advancements, with an equally high approval rate (91.8%). This suggests that the public recognizes that technological progress is inseparable from the role of scientists who continuously conduct research and innovations. Studies indicate that scientists must actively engage in public communication to bridge the gap between technological advancements and public understanding [55]. However, despite being acknowledged as key drivers of technological change, there remains a disconnect between the scientific community and societal readiness to adopt new innovations. This challenge is evident in issues such as artificial intelligence, renewable energy, and biotechnology, where scientific advancements often outpace regulations, ethical considerations, and public understanding of these technologies [56].

Although Scientists play a highly vital role, the extent of their involvement in policy-making remains questionable. In many cases, decisions with significant environmental or public health impacts are often more influenced by political and economic factors rather than scientific recommendations. For instance, in climate change discussions, despite scientists having long warned about the consequences of greenhouse gas emissions, global policies have yet to fully reflect the urgency emphasized by the scientific community [54]. This indicates that while scientists hold high credibility in the public eye, their voices are not always fully accommodated in strategic public policies. The engagement of scientists in public dialogue and policymaking is essential to ensure that scientific knowledge is effectively integrated into decision-making processes [57].

Beyond policy challenges, scientists must also adapt to changes in how scientific knowledge is communicated in the digital age. Information technology has transformed how society accesses and understands science, presenting both opportunities and threats. On one hand, access to scientific information has become easier through the internet and social media, but on the other, misinformation and misinterpretation of scientific findings have also become more widespread [53][58]. Scientists need to be more proactive in educating the public and participating in public discussions to ensure that accurate scientific knowledge is widely disseminated and not easily manipulated by parties with specific interests [52]. Thus, the role of scientists in science communication in the digital era has become increasingly critical in building public trust and ensuring that scientific information is accessible and correctly understood by society [59].

Overall, the high level of public trust in the role of Scientists in advancing science and technology is a positive indication that this profession remains highly respected and valued. However, the main challenges that need to be addressed include ensuring that their research findings can be effectively implemented, amplifying the voices of scientists in policymaking, and strengthening science communication so that society is better prepared to adapt to changes driven by technological advancements. If scientists' engagement in social, political, and public communication domains can be enhanced, their role in shaping a more innovative and sustainable future will be maximized.

Conclusion

Science teachers' perceptions of IPA scientists indicate a high appreciation for their role in science and technology while also reflecting various challenges related to representation, science communication, and professional appeal. Classical figures such as Einstein, Newton, and Curie continue to dominate the public image of scientists, whereas contemporary scientists receive inadequate exposure. Although IPA scientists are respected for their expertise, persistent stereotypes regarding gender, age, and appearance may influence the attractiveness of this profession to younger generations. Trust in the scientific method remains high; however, misconceptions about the dynamic nature of scientific knowledge persist, potentially fostering skepticism toward changes in scientific research. The relationship between scientists and society also exhibits gaps, particularly in terms of engagement in education and public communication, leading to the perception that scientists are distant from everyday life. While the majority of respondents do not perceive scientists as individuals who lack religious commitment, a small percentage still associate them with

secularism, highlighting the need for broader discussions on the intersection between science and spiritual values. The profession of IPA scientists is still considered appealing by most respondents, yet challenges such as financial security, media exposure, and the perception of science as overly serious remain obstacles for younger generations to pursue careers in this field. Finally, despite widespread recognition of their crucial role in addressing contemporary challenges, the influence of IPA scientists on public policy remains limited, and science communication efforts need further reinforcement to ensure that scientific innovations are more accessible and accepted by the broader public. Therefore, systematic efforts from various stakeholders are necessary to enhance scientists' involvement in education, science communication, and public policy, thereby maximizing their role in shaping a more innovative and sustainable future.

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