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Article

The character model of a scientist: Structure and role

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Abstract: People have been studying the characteristics of scientists for more than 100 years. Some related studies have drawn on concepts and methods from fields such as psychology, cognitive science, ethics, and behavioral science, proposing certain incomplete perspectives. However, systematic research in this area remains insufficient to date. Based on a literature review and theoretical analysis, this study integrates research findings from modern psychology, cognitive science, ethics and moral science, and behavioral science to propose a systematic theoretical framework for the character of a scientist. The study introduces a novel definition of these traits, elucidates their constituent elements, and establishes a theoretical model for describing the characteristics of scientists. This paper also discusses the close connections between the scientist model and the Big Five Personality Model, Rational Cognitive Style Theory, Schwartz Value Theory, and Habit Behavior Theory, as well as the relationships among the various dimensions of the model. The proposal and dissemination of the scientist character theory will facilitate the objective selection of future scientists and researchers, as well as the acquisition and enhancement of their scientific research skills, ultimately advancing the progress of scientific research. Simultaneously, it may exert positive potential impacts on science communication, public understanding of science, and the development of scientific culture and science education.

Keywords: scientists' character; character model of scientists; role; scientific education; science study

1. Introduction

Scientific research is not an industry with a long history, but it has played a great role in promoting the development of human beings and social progress. Scientists, as the core of scientific research, are widely respected. The term "scientist" in this article refers to all individuals engaged in scientific research and is not limited to renowned scientists. To date, there has been limited academic research on the character of scientists from a macro or systematic perspective. However, studies examining the traits of scientists from the perspectives of personality traits, thinking patterns, values, and behavioral patterns have been frequently reported (Lewis and William, 1882; Anne, 2008; Martínez-Romera, 2018).

Regarding research on the structural dimensions of the Character Model of Scientists (CMS), Snowden (1917) asserted that the scientist's character comprises truth-seeking, honesty, exploration, kindness, withstanding frustration, and perseverance. Feist (1993) studied the structural models of eminent scientists and noted that the model included five factors: demographic, personality, working style, motivational, and productivity. Cai (2003) described the scientist's character as containing "at least the following six elements: the objective basis, rational skepticism, pluralistic thinking, affirmative argument, the test of practice, and generous incentives." Nehru (2004) pointed out that a scientific temperament should become a way of life, a mode of thinking, a code of conduct, and a means of interacting with fellow human beings. Samuel (2012) stated that the personality traits of information scientists are mainly manifested as "inquiry" and "pursuit of achievement". Scientists score higher on "openness" and "perseverance" compared to non-scientists (John et al., 2012). Scientific temper is described as having four dimensions: scientific literacy, rational thinking, inquiry spirit, and causality (Shaila, 2019). Peng and Tang (2021) believed that the qualities of scientists comprise rational thinking, questioning and criticism, and inquiry. As discussed earlier, research on the structural dimensions of scientific personality traits by scholars has adopted multidimensional perspectives, with varying focal points. Regarding the constituent factors of the CMS, John (1990) discusses the personality traits of highly creative people that these people can often be described by the following adjectives: clever, confident, egotistical, humorous, individualistic, informal, insightful, intelligent, having wide interests, inventive, original, reflective, resourceful, self-confident, and unconventional. Visser (2000) wrote:

The scientific mind is a complex mindset. The following suggestions are offered as a starting point for the description of its multidimensional character: (1) The spirit of inquiry; (2) The spirit of collaboration; (3) The quest for beauty (harmony, parsimony, wholeness); (4) The desire to understand and do so profoundly; (5) The creative spirit; (6) The urge to be critical; (7) The spirit to transcend; (8) The spirit of building on prior knowledge; (9) The search for unity; (10) The building of the story of human knowledge and ability; (11) The spirit of construction. (p. 6).

Qin (2006) said that "scientists who are advocating the truth reality, seeking truth, perseverance, perseverance to explore, skeptical, dare to challenge, dare to innovate, stick to their selfless dedication, the sentiment, quality and behavior character." (p. 3).

Anne described Albert Einstein, as a famous scientist, to have fully demonstrated "curiosity", "assertiveness", "questioning and criticism", "pursuit of achievement", "inquiry", "contribution to society" and "perseverance" in his legendary scientific research career. Saxena (2014) said that scientific temper refers to a frame of thinking without superstition, prejudice, rigidity, obscurantism, closed-mindedness, irrationality, subjectivity, or any other narrow-minded tendencies. Han (2021) summarizes the ethos of scientists: rational, realistic and pragmatic, skeptical and critical, bold exploration, pioneering and innovative, open and tolerant, exhibiting practice, collaboration, and democracy. The aforementioned publications taken together reveal that the field of research has produced abundant evidence characterizing the constitutive factors of the Scientist Structural Model, with some consensus observed. However, from the perspective of dimensions in the Scientist Trait Structural Model, certain constitutive factors remain undescribed.

Schwartz (2012) studied human values, putting forward a basic theory of values, characterizing the basic human values of self-direction, stimulation, hedonism, achievement, power, security, conformity, tradition, benevolence, and universalism. Heath (1964) proposed four cognitive preferences: memory of specific facts or terms, practical application, critical questioning of information, and identification of a fundamental principle. Khine (2012) describes the work of scientists as a "practice based on logical analysis of empirical evidence and critical thinking." The researchers were then able, thorough discussion, to agree on the component factors of critical thinking, but the component factors of logical analysis of empirical evidence were reported to be excessively complex.

In summary, although people have studied the characteristics of scientists for one hundred years, there are still some aspects of the work to be clarified: (1) Previous research on the characteristics of scientists is scattered across many research fields, and lacks any system or coherence; (2) No consensus has yet been reached on an accepted definition of the characteristics of the scientist; (3) No work has yet described a Character Model of Scientists (CMS) not have the applications of such a model been explored. Progress in this field will promote and improve science communication, science education, training of scientific researchers, selection of scientific researchers, and the development of scientific research. For these purposes, we will aim to answer the following questions:

(1) What is the definition of a scientist's character?
(2) What are the constituent elements of a scientist's character?
(3) What are the structural dimensions of the CMS?
(4) What is the CMS?
(5) What is the role of the CMS?

2. Methods

A literature search was conducted to identify articles and books where the keywords contained "scientist's character", "scientist's characteristic", "scientist's traits", "scientific spirit", "scientist's thinking style", "scientist's cognitive preference", "scientist's value", "scientist's personality traits", "scientist's habit behavior", or "scientific temper" using Web of Science, Elsevier, Taylor & Francis Group, ResearchGate, Academia, Google Scholar and the China National Knowledge Infrastructure (CNKI). A total of 254 records were collected. The 254 records were screened according to the inclusion and exclusion criteria outlined below. Inclusion criteria: (1) The article topics should cover scientists, scientific researchers, or the scientific spirit. (2) The content should address aspects such as personality traits, cognitive preferences, values, or habitual behaviors. (3) The article must analyze and discuss at least two specific dimensions or aspects from the aforementioned four categories. Exclusion criteria: (1) Articles involving non-scientists, non-researchers, or topics unrelated to the spirit of science. (2) Articles analyzing fewer than two specific aspects of the four dimensions or related areas. After screening, a final cohort of 24 articles was included in the study. The resulting records were collated and summarized to characterize relevant existing research and identify existing problems in the field. This resulting summarized list was analyzed in combination with the authors' own perspectives, to facilitate the generation of advancements to the research field, with the aim of constructing a CMS. Then, the role of the CMS was described.

3. Findings

3.1. The definition of a scientist's character

Previous words used to describe the "scientist's character" include the scientist's traits, the scientist's personality, and the scientist's characteristics. Although some researchers have studied the scientists' character from different perspectives, no single name to completely describe the scientists' character was widely agreed upon. This paper proposes that the term should be the "scientist's character". To distinguish between the character and traits, personality, and characteristics of a scientist. The present article defines the "scientist's character" as follows: the combination of some characteristics of scientific researchers embodied in their work and life, including, but not limited to values, personality traits, cognitive preferences, and habits and behaviors.

3.2. The constituent elements of the scientist's character

We conducted a textual analysis on the included 24 studies using MAXQDA software to identify high-frequency terms related to personality traits, cognitive preferences, values, and habitual behaviors. Subsequently, we filtered out synonyms and near-synonyms based on professional definitions and concepts from psychology, neuroscience, cognitive science, and ethics. Finally, the top four most frequently used terms within each of four dimensions (1. personality traits; 2. cognitive preferences; 3. values; and 4. habitual behaviors) were selected for this study. These 16 terms, grouped by dimension, comprised: (1) Personality traits: having curiosity, openness, assertiveness, and honesty; (2) Cognitive preferences: rationality and objectiveness, attaching importance to logic, questioning and criticism, rational reasoning; (3) Values: self-direction, justice, pursuit of achievement, contribution to society; and (4) Habitual behaviors: inquiry, toeing the line, perseverance, and cooperation. This result yields a summary list containing 16 constituent elements (see **Table 1**). These 16 constituent elements may not completely describe the scientist's character, but merely cover the most frequently mentioned elements. **Table 1** presents the frequency distribution of these 16 elements across the 24 articles analyzed. Furthermore, David's (2007) compilation, The 1000 Wisest Things Ever Said by Nobel Prize Laureates, highlights that many laureates have referenced these 16 dimensions in varying degrees across their speeches and writings. MAXQAD's word frequency analysis confirms that certain terms from these dimensions were particularly embodied by the Nobel laureates (see **Figure 1**).

Table 1. The source of the constituent elements of a scientist's character.

Researcher (year)	HC	OP	AS	HO	RO	AL	QC	RR	SD	JU	PA	CS	IN	TL	PE	CO
Lewis and William (1882)	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓			
Snowden (1917)				✓	✓			✓			✓		✓		✓	
Miller (1936)				✓							✓		✓			
Nature (1936)				✓	✓		✓				✓		✓		✓	
Chiang (1943)											✓				✓	✓

Table 1. *Cont.*

Researcher (year)	HC	OP	AS	HO	RO	AL	QC	RR	SD	JU	PA	CS	IN	TL	PE	CO
Harrison and Donald (1960)	✓	✓			✓	✓			✓		✓		✓		✓	✓
Merton (1973)		✓			✓		✓					✓				
Andrews (1973)		✓		✓	✓		✓		✓			✓	✓		✓	✓
McLaern (1980)				✓	✓		✓				✓					
Lefkowitz (1988)	✓			✓									✓		✓	
AAAS (1990)	✓			✓	✓	✓							✓			
Anita (1992)	✓		✓		✓		✓					✓				
Petkova and Boyadjieva (1994)		✓		✓	✓		✓	✓		✓	✓	✓				
Visser (2000)				✓			✓				✓		✓			✓
Cai (2003)					✓		✓						✓		✓	
Qin (2006)					✓		✓				✓	✓	✓		✓	
Anne (2008)	✓		✓				✓		✓	✓	✓	✓	✓		✓	
Sheldrake (2012)		✓					✓						✓			
Schwartz (2012)			✓						✓	✓	✓		✓	✓		✓
Lee (2013)	✓				✓	✓		✓								
Saxena (2014)	✓	✓			✓		✓						✓			
Sato (2016)	✓	✓	✓						✓							
Martínez-Romera (2018)		✓	✓		✓	✓	✓		✓					✓	✓	✓
Bucchi et al. (2019)											✓	✓	✓		✓	
Chen and Song (2020)	✓				✓	✓					✓		✓		✓	✓
Peng and Tang (2021)					✓								✓			
Zheng et al. (2021)					✓		✓						✓			
Sezgin (2021)	✓	✓		✓	✓		✓				✓	✓	✓		✓	
Han (2021)		✓			✓		✓						✓			✓

Note: HC=having curiosity; OP=openness; AS=assertiveness; HO=honesty; RO=rationality and objectiveness; AL= attaching importance to logic; QC=questioning and criticism; RR=rational reasoning; SD=self-direction; JU=justice; PA=pursuit of achievement; CS=contribution to society; IN=inquiry; TL=toeing the line; PE=perseverance; CO=cooperation.

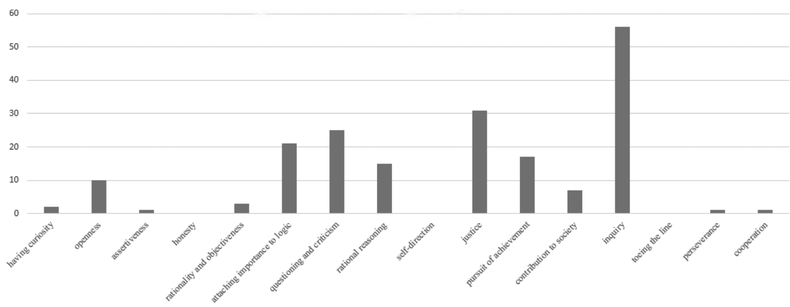

Figure 1. Graphical visualization of the frequency with which the 16 terms appeared.

The summary of the 16 constituent elements of a scientist's character is shown in **Table 2**.

Table 2. The description of the constituent elements of scientist's character.

Constituent elements	Description
HC	Being curious about nature and the unknown, and driven by curiosity, according to their own rational decisions.
OP	Having a broad mind, embracing change and development, quickly integrating into a new world.
AS	Having self-reliance, self-improvement, self-confidence, self-esteem, self-love and reasonable pride.
HO	Having honesty and integrity.
RO	Being rational, reasonable, objective, and based on the facts.
AL	Attaching importance to logic, following the law of logic to analyze problems and make decisions.
QC	Having strong doubts, not worshipping authority, adhering to independent thinking, having the skills and methods of critical thinking, and using them in practice.
RR	Being rational, reasoning and making judgments according to reasonable logic.
SD	Having self-orientation, self-restraint, autonomous planning, autonomous action, and self-motivation.
JU	Advocating fairness and justice.

Table 2. *Cont.*

Constituent elements	Description
PA	Actively pursuing achievement and self-actualization.
CS	Paying attention to public well-being and actively contributing to society.
IN	Paying attention to the inquiry, adhering to the investigation and analysis, having rational access to the correct results.
TL	Abiding by the rules and handling affairs in accordance with the rules.
PE	Having perseverance, resilience, and keeping moving forward.
CO	Having an open attitude, mutual cooperation, willingness to cross institutions, practicing cross-regional cooperation.

Note: HC=having curiosity; OP=openness; AS=assertiveness; HO=honesty; RO=rationality and objectiveness; AL= attaching importance to logic; QC=questioning and criticism; RR=rational reasoning; SD=self-direction; JU=justice; PA=pursuit of achievement; CS=contribution to society; IN=inquiry; TL=toeing the line; PE=perseverance; CO=cooperation.

3.3. The structural dimensions of the CMS

There is little past research on the dimensions of the CMS. In this paper, we summarized the research content of previous studies across many fields, combined with research findings from contemporary psychology, behavioral science, and ethics. We put forward the dimensions of the CMS and elaborated on these dimensions (see **Table 3**).

Table 3. The dimensional structure of the character model of the scientist (CMS).

Dimension	Description
Personality traits	The four most common personality traits that scientists generally have: having curiosity, openness, assertiveness, honesty.
Cognitive preference	The four most common cognitive preferences that scientists generally have: rationality and objectiveness, attaching importance to logic, questioning and criticism, rational reasoning.
Values	The four most common values that scientists generally have: self-direction, justice, pursuit of achievement, contribution to society.
Habits and behaviors	The four most common habits and behaviors that scientists generally have: inquiry, toeing the line, perseverance, cooperation.

It should be noted that, with regard to the structural dimensions of the CMS, the four elements attributed to each dimension do not necessarily provide an exhaustive list of all the elements of this dimension, but only the most fundamental and frequently occurring four elements. In addition, there may be ambiguity and overlap between the dimensional classification assigned to individual elements, but this is only an exception. This also does not affect the reliability of the model's dimensions.

3.4. CMS

The CMS consists of four dimensions, and each dimension is composed of four elements, which together constitute a complete CMS (see **Figure 2**).

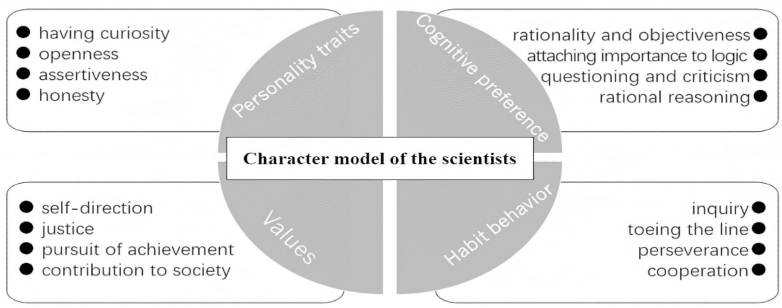

Figure 2. The four dimensions of the complete CMS and the four elements comprising each dimension.

3.5. The role of the CMS

One clear role of the CMS is to help provide an answer to a child's question: "How can I become a scientist?" In doing this, we need to answer the following questions: (1) What needs to be done to train scientific researchers? (2) What characteristics make people more suited to scientific research? (3) Which criteria should be prioritized in the selection of scientific researchers? (4) What factors may predict scientific research performance? The answers to all these questions are intrinsically linked to the scientist's character, and therefore the CMS. The CMS, therefore, has implications for scientific research, science education, science communication, and public understanding of science in contemporary society. The specific uses of this are demonstrated as follows:

1. Science education: (1) The CMS should be covered in science education textbooks. The breadth and depth of CMS content will need to be made appropriate for different stages of education, from primary school to graduate school, but with similar learning objectives throughout. As a student progresses through the system, their understanding of brain science, thinking science, personality theory, cognitive theory, and behavior theory will benefit from an overarching understanding of the CMS. Inclusion of the CMS may become a criterion for textbook selection, provided it aligns with the framework described here or relates closely to established views on the nature of scientific research. (2) The CMS should form part of science teacher training, as effective teachers are needed to produce qualified students. (3) The relevant elements of the CMS should be added to graduate admissions processes to facilitate a broader assessment of the applicants' potential for scientific research. (4) The CMS has the potential to enhance science education by cultivating greater enthusiasm in science, developing future scientists, and enhancing public understanding of science.
2. Science communication: (1) The CMS can be used in the training of science communication practitioners, enhancing their understanding of science as well as their cognitive and communication skills. (2) Familiarity with the CMS has the potential to strengthen communication, exchange, and collaboration between science communication practitioners and scientific researchers.
3. Public understanding of science: (1) Clear, concise, and visually engaging diagrams and infographics of the CMS can be used in science communication textbooks to support public understanding of science and build enthusiasm for participating in science communication. Over time, this will enhance public scientific literacy and interest. (2) A general public understanding of basic CMS theory may facilitate more effective communication and interaction with scientific researchers and science communication practitioners. (3) By supporting improvements in science communication, the CMS may contribute to greater public engagement with science. At a broader level, the CMS may have a socio-economic impact due to the role of scientific research and technological progress in societal development.

4. Science research: (1) The CMS may inform the criteria used in the selection of scientific researchers to improve the efficiency of such processes and maximize the effectiveness of the scientific community. While no individual is expected to exhibit all CMS elements, employing a greater number of people embodying CMS attributes and characteristics is likely to foster an environment suited to the needs of scientific research. (2) As part of professional training for early career researchers, the CMS may enhance training effectiveness. Components relating to "values" and "habitual behavior" may be more readily developed, while those associated with "personality traits" and "cognitive preferences" are more likely to be complex due to individual variability in the personality traits of participants. (3) CMS education starts by outlining key dimensions: "values", "habitual behavior", "personality traits", and "cognitive preferences", with the aim of developing cognitive, practical, and evaluative skills relevant to scientific research. This approach has the potential to contribute to improved research design, reduce the likelihood of scientific projects being abandoned, and enhance the resilience of research processes to uncontrollable factors that may prevent successful completion, while also reducing the risk of errors arising from oversight and situational factors.

4. Discussion

This study presents the first clear and comprehensive definition of the scientist's character, identifies its constituent elements, and outlines the structural dimensions of the CMS, while illustrating its potential roles. In doing so, this work breaks through the partial definitions provided in previous studies that have been limited to a few disparate academic fields. The CMS presented here emphasizes the need for systematization and coherence of the definition across multiple disciplines.

The 16 constituent elements defined in this paper are based on a systematic review of previous findings across multiple fields, informed by research from contemporary psychology, ethics, and behavioral science. These findings are also consistent with established evidence describing the nature of science. For example, the American Association for the Advancement of Science (1990) identified that science (1) demands evidence, (2) is a blend of logic and imagination, (3) explains and predicts, and (4) identifies and minimizes bias. Similarly, Ji (1991) argued that "science has made incarnate some time-honoured ideals, such as creativity, open-mindedness, aggressiveness, authenticity, verifiability, falsifiability, equality, applicability, and, all in all, rationality" (p. 109). Lee (2013) reported that science (1) is based on empirical evidence; (2) relies on observation and inference; (3) values both reasoning and imagination (creativity); (4) aims to be objective and to minimize bias; (5) values skepticism and critical thinking. Sheldrake (2012) stated that the skeptical nature and spirit of open-minded enquiry are at the heart of scientific creation. Findings from a survey of 133 Chinese scientists conducted by Chen and Song (2020) were presented in the form of 16 factors: cooperation, innovation, intense interest, keen intuition, rigor, curiosity, focus on improving ability, persistence, broadness of knowledge, efficiency, perfectionism, modesty, outstanding early performance, effective exploration, hard work, and efficient learning.

This study develops the structural dimensions of CMS and proposes a comprehensive model, thereby establishing a systematic theoretical framework for describing the character of scientists. This theoretical framework draws on established theories, icluding the Big Five personality model theory of personality from psychology, rational cognitive style theory from cognitive science, and Schwartz's theory of values and habitual behavior theory from behavioral science.

The Big Five personality model comprises five independent dimensions: openness to experience (or open-mindedness), conscientiousness, extraversion, agreeableness, and neuroticism (or negative emotionality) (Sier et al., 2022). These established features are strongly represented by the elements of openness, cooperation, and conscientiousness in the present model. Sadler-Smith (2004) proposed the theory of rational cognitive style, which is characterized by objectivity, seriality, convergent thinking, logicality, and meticulousness. This is reflected in the cognitive preference dimension of the present model. Schwartz's theory of values (Sagiv and Schwartz, 2022) comprised ten fundamental human values: self-direction, stimulation, hedonism, achievement, power, security, conformity, tradition, benevolence, and universalism. These are also represented in the proposed model. Gardner et al. (2024) define habitual behavior as that which is habitually instigated or habitually executed or both. While Chen and Song focused on the personality traits of scientists, the 16 traits they proposed included intense interest in science, persistence, rigor, and cooperation, which are habitual behaviors, and furthermore are consistent with the four factors in the habitual behavior dimension of the present model. Moreover, the theoretical framework developed in this study is supported by previous research findings on the characteristics and ethos of scientific practice. For example, Snow (1998) proposed that "there are common attitudes, common standards and patterns of behaviour, common approaches and assumptions" in academia, while Wang (2005) proposed that the scientific ethos should include values, patterns of behavior, behavioral norms, and scientific activities. Su (2013) further stated that "scientific ethos is a kind of ideal spirit temperament which is embodied by the scientific group's behavior standard, which includes many factors, such as scientific attitude, scientific method, and scientific style" (p. 59). These findings can be discussed in the context of Kolb's learning styles model, where the number of assimilators is relatively large (up to 60% of the participant cohort; Zhou et al., 2023). Assimilators are characterized by a preference for observation and thinking, features strongly aligned with the CMS, demonstrating that the CMS may help guide scientific researchers to achieve better learning efficiency, accuracy, productivity, and impact.

The CMS model (see **Figure 2**) comprises four dimensions, each consisting of four constituent elements, and exhibits the following fundamental properties: (1) The four dimensions comprehensively encompass innate genetic and intellectual factors, personality traits, thinking patterns, value systems, and habitual behaviors, demonstrating inherent structural integrity. (2) The model significantly influences behavioral activation, maintenance, and outcomes. (3) Personality dimensions within the model exert certain constraints on or influence the remaining three dimensions.

(4) The dimensions within the model are non-substitutable. (5) Some dimensions within the model exhibit complementary relationships. (6) Within each dimension, all elements carry equal weight. (7) Within each dimension, factors are non-substitutable. (8) Some elements within each dimension exhibit complementary characteristics. Supporting evidence for these properties can be found in previous studies (Louwen et al., 2023; Farsad and Modarresi, 2022; Fatima et al., 2025 ; Riding, 1997; Blomstervik and Olsen, 2026; Hagger et al., 2020).

It should be noted that the elements of the upper half of the model of CMS are more influenced by heredity, personality traits, psychological characteristics, and thinking styles, and may be less affected by environmental factors. Consequently, these elements are likely to be more challenging to modify through education and training. Conversely, the elements of the lower half of the model may be more readily influenced by environmental factors, and improving these elements through education and training is more likely to be achievable.

This study outlines the role of the CMS, how it can influence science education, science communication, and the public understanding of science, with the ultimate objective of improving public scientific literacy, better identifying, attracting, and supporting students with the motivation and aptitude for scientific research, improving the reliability of researcher selection processes, and strengthening the skills and motivation of scientific researchers. Additionally, the CMS may support the development of researchers' learning abilities and improve learning effectiveness.

5. Limitations and future research

The present findings are based primarily on theoretical analysis and lack evidence from empirical validation. There may be cultural biases in the definition of the scientist's character and potential overlaps between conceptual dimensions. Future research should address these limitations by developing and validating measurement scales for the CMS, including the use of exploratory and confirmatory factor analyses. In addition, empirical studies in fields such as scientific education, the training and selection of scientific researchers, and the practice of scientific research will be needed to further evaluate and support the proposed framework.

6. Conclusion

This study provides a comprehensive description of the characteristics associated with effective scientific researchers, including personality traits, cognitive preferences, values, and habitual behaviors. Building on previous findings, is develops the conceptual framework, structural dimensions, and model hierarchy of CMS, with the aim of establishing a foundational theoretical system. The formulation and dissemination of the CMS aims to improve the objectivity of researcher selection and the efficiency of researcher development, ultimately supporting the advancement of scientific research. This work may also have broader implications for science communication, the public understanding of science, science education, and the development of scientific culture.

Abbreviations

character model of scientists = CMS.

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