frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 10 October 2025
DOI 10.3389/feduc.2025.1667782

OPEN ACCESS

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RECEIVED 30 July 2025
ACCEPTED 25 September 2025
PUBLISHED 10 October 2025

CITATION
Cheng J, Lu Y, Wang K, Zhang M and Chen S (2025) Integration of the history of science in China's geography textbooks: a comparative analysis of current versions of eight junior high school textbooks. *Front. Educ.* 10:1667782. doi: 10.3389/feduc.2025.1667782

Integration of the history of science in China's geography textbooks: a comparative analysis of current versions of eight junior high school textbooks

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Introduction: The presentation of the history of science (HOS) in textbooks plays a vital role in fostering scientific literacy, as its selection and pedagogical implementation directly influence the quality of student learning.
Methods: This study applied a revised analytical framework for HOS, which encompasses four themes and ten dimensions: thematic content, presentation modes, pedagogical activities, and value orientations. Based on this framework, a comparative analysis was conducted across eight current versions of junior high school geography textbooks in China.
Results: The analysis revealed that (1) the overall quantity of HOS content is limited across textbooks. Within thematic content, "significant events and expeditions" are most common, whereas "geographers and explorers" are least represented, with varied emphases on sources of HOS. (2) In terms of presentation, HOS is predominantly delivered through text-image integration in the "Main Body" and "Supplementary Reading" sections, though unevenly distributed. Integration depth is primarily intrinsic and supplementary, showing exploratory potential. (3) Pedagogical activities are mainly optional, with notable variation in cognitive levels across versions: some emphasize foundational tasks, while others stress deepening activities. Guided reading and inquiry-based discussion dominate, though overall diversity of activities is lacking. (4) The epistemological and cultural orientations are relatively monolithic, focusing on discipline-specific knowledge over humanistic or philosophical perspectives. Attitudinal orientations are mostly neutral or positive.
Discussion: These findings indicate that while HOS is included in junior high school geography textbooks, its representation remains limited and uneven in both content and pedagogy. Enhancing the diversity of HOS content, presentation, and learning activities, as well as broadening its value orientations, may contribute to more comprehensive cultivation of scientific literacy.

KEYWORDS

science education, history of science, geography textbook, textbook analysis, China

1 Introduction

Amid a global movement toward science education reform and the promotion of scientific literacy (SL), understanding the nature of science and its social dimensions has emerged as a central objective of science education (Organisation for Economic Co-operation Development, 2023). In response to this trend, China has promulgated key policy documents, including the *Outline of the National Scheme for Scientific Literacy Action* (2021–2035) and the *Opinions on Strengthening Science*

Education in Primary and Secondary Schools in the New Era, to bolster the cultivation of SL in basic education (The State Council of the People's Republic of China, 2021; Ministry of Education 18 Other Departments, 2023). Within this context, the history of science (HOS) is recognized as a critical pedagogical tool. HOS, which functions as a conduit between science and society, is instrumental in fostering students' SL by enabling them to scrutinize the trajectory of scientific discoveries, the evolution of scientific knowledge, and the sociocultural contexts in which they are embedded (Gurgel and Watanabe, 2020; Yildirim and Kececi, 2024). Consequently, educational reforms worldwide have increasingly advocated the integration of HOS into science curricula. For instance, the Next Generation Science Standards (NGSS) in the United States explicitly embed the understanding that "scientific knowledge is open to revision in light of new evidence," thereby reinforcing students' comprehension of the nature of science (NGSS Lead States, 2013).

Textbooks serve as primary vehicles for knowledge transmission and as a medium for cultural reproduction within formal education (Vygotsky, 1986). Because teachers predominantly draw upon textbooks for instructional materials, the selection and portrayal of the HOS within these texts profoundly influence the development of students' SL. Thomas Kuhn distinguished between the HOS as presented in textbooks and the HOS itself, emphasizing that textbook-based HOS exists as a necessary condition of scientific practice. Although the historical narratives in textbooks are often simplified or reconstructed, they play a crucial role in consolidating and disseminating scientific paradigms (Kindi, 2005), while simultaneously shaping students' views of the nature of science and their perceptions of scientists (Chang, 2016; Lin et al., 2023). Constructivist learning theory further supports the integration of HOS into textbooks. Inquiry-based activities grounded in historical episodes of science—such as formulating scientific questions, attending to evidence, and developing explanations—align closely with the constructivist emphasis on learners' active engagement, exploration, and reflection in building their own knowledge and understanding, thereby fostering students' critical thinking (Pellegrino et al., 2018).While substantial scholarly attention has been devoted to the integration of HOS in disciplines such as physics and chemistry, a conspicuous gap exists in the literature concerning its systematic incorporation into earth science and geography curricula. This oversight is noteworthy because earth science is a foundational, comprehensive, and practice-oriented science course in secondary education that includes fields such as astronomy, geology, meteorology, and oceanography (Jo and Jeong, 2016).

Within the Chinese educational context, the geography curriculum functions as the principal carrier of earth science education. It is an integrated course that synthesizes diverse natural science topics, including geology, meteorology, and environmental science, while simultaneously emphasizing the human-environment relationship and spatial systems thinking, thereby offering a unique vantage point for cultivating SL (Duan and Ding, 2025; Xuan et al., 2019). This distinctive role can be attributed to both the long-standing history and the disciplinary inclusiveness of geography in China. Historically, Chinese geography evolved from early descriptive accounts of geographical knowledge, through the modern era's analytical exploration of spatial laws, toward the contemporary capacity for simulating and predicting complex human–environment systems, a trajectory that closely parallels the development of earth system science. The inclusion of HOS in geography is particularly salient because it represents an "evolutionary atlas of geospatial cognition" that comprises the historical methods of discovering, understanding, and evaluating geographic phenomena (Martin, 2008). This approach helps students comprehend spatial differences on the Earth's surface and explore the methodologies used to explain them. However, a debate persists in China's curriculum reform regarding the disciplinary positioning of "earth science" vs. "geography," with some scholars questioning the efficacy of the current system to adequately cultivate SL (Hu, 2024). It is hypothesized that the inadequate integration of HOS may be a contributing factor to this perceived deficiency. Nevertheless, this proposition lacks empirical validation, highlighting a critical need for research that investigates the status of HOS within China's secondary school geography textbooks.

Given the aforementioned research gap and the pivotal role of geography textbooks in China, the present study aims to address this issue through a systematic investigation. Using a content analysis methodology, a novel analytical framework is developed to examine HOS in geography education. Subsequently, this framework is applied to conduct a comparative analysis of eight contemporary junior high school geography textbooks that were recently published in China. These textbooks are examined to identify the current status, distinctive characteristics, and potential deficiencies in their integration of HOS with a focus on four key dimensions: content selection, presentation format, associated learning activities, and underlying value orientations. By doing so, this research seeks to provide evidence-based recommendations for the future development of geography textbooks and to increase the cultivation of SL in geography education. Furthermore, this study contributes a valuable case study from China to the international discourse on HOS in geography education.

2 Literature review

2.1 The unique role of the history of science in earth science education

In an era of intensifying global competition, a paradigm shift in science education has been observed from a primary focus on knowledge transmission to the cultivation of SL among citizens. The integration of HOS is widely regarded as a pivotal strategy for improving students' understanding of the nature of science (NOS) and fostering SL (Matthews, 2014; McComas, 2008). Among the diverse scientific disciplines, Earth science is distinguished by its view of the Earth as a complex, integrated system. This field encompasses the study of the solid Earth, surface systems, and solar–terrestrial space system and examines the intricate interactions between the Earth's spheres and anthropogenic impacts on the planet (Lawton, 2001; Steffen et al., 2020). Consequently, Earth science education is crucial for equipping future citizens to address complex environmental issues and promote sustainable

development (Mayer, 1995; Vasconcelos and Orion, 2021). Within this context, HOS, which is defined as the discipline that chronicles the formation, evolution, and societal relevance of scientific knowledge (Bächtold, 2012), holds a position of unique value. Although a formal consensus on the precise composition of HOS within earth science is still emerging, it generally encompasses the history of scientific discoveries, the philosophy of science, and the dynamic interplay between science and society (Kleinhans, 2021).

The scholarly literature underscores the significant potential of integrating HOS into Earth science curricula. By elucidating the formation of scientific concepts and the evolution of scientific methods, HOS can deepen students' comprehension of the nature of science (Boerner, 2014; Davis, 2010; Dolphin and Dodick, 2014). Furthermore, the use of historical case studies, scientific controversies, and biographical narratives of scientists serves to stimulate student interest and foster critical thinking skills and an inquisitive mindset (Coen and Jonsson, 2022; Dolphin and Dodick, 2014). Finally, HOS acts as a conceptual bridge between the natural and social sciences and helps students appreciate the intricate connections between scientific endeavors and societal contexts. This understanding can cultivate greater concern for contemporary social issues, enhance students' sense of social responsibility (Vasconcelos and Orion, 2021), and strengthen their engagement in scientific practices (Cansiz, 2024).

2.2 Analytical frameworks for the history of science in textbooks

Textbooks serve as the central instrument for curriculum implementation, which makes them a crucial tool for integrating HOS into classroom instruction. Consequently, the analysis of HOS content within study materials has emerged as a significant research domain in science education. The strategic integration of HOS is considered beneficial because it contributes substantially to shaping students' perceptions of the NOS (Pellegrino et al., 2018) and their understanding of scientists (Osmanoglu, 2020; Tsai and Liu, 2005). Furthermore, HOS content functions as a sociocultural conduit that enables students to engage with the activities of scientists within their specific historical contexts (Guney and Seker, 2012), thereby fostering a deeper appreciation for scientific culture.

To systematically evaluate the quality of HOS representation, researchers have developed sophisticated analytical frameworks for categorizing and quantifying HOS content. For instance, Wang (1999) analyzed HOS in four U.S. middle school physics textbooks and the National Science Education Standards (NSES), which led to the construction of a three-dimensional framework that included "understanding of scientific knowledge," "understanding of scientific methods," and "the relationship between science, technology, and society." The findings indicated that despite the substantial inclusion of HOS content, its presentation was largely superficial and lacked the requisite depth for fostering genuine inquiry, which impeded a comprehensive grasp of scientific concepts (Wang, 1999). Building on these efforts, Leite (2002) examined five physics textbooks and proposed a more comprehensive eight-dimensional framework. The credibility and validity of this framework, which included dimensions such as "type and organization of the historical information" and "correctness and accuracy of the historical information," were substantiated by its application in the quantitative analysis of HOS content derived from qualitative coding.

Leite's (2002) analytical framework has been extensively applied and adapted in subsequent research. For example, Ma and Wan (2017) refined Leite's framework from a cultural perspective to investigate HOS content in 19 sets of Chinese textbooks from various periods. Their study revealed that the cultural depth of HOS content was largely insufficient and exhibited notable variations across scientific disciplines. More recently, Lin et al. (2023), building upon Leite's model, investigated HOS content in the two latest editions of Chinese high school physics textbooks and highlighted their distinct characteristics and the divergence between them. Consequently, the adoption of Leite's framework in conjunction with both quantitative and qualitative methodologies has become a predominant trend. Emphasis has also been placed on refining this framework to align with specific disciplinary characteristics.

Despite these analytical advancements, however, consensus in the literature suggests that HOS content in contemporary science textbooks remains limited and exhibits several deficiencies (Ma and Wan, 2017). These include, but are not limited to, a notable paucity of depth and contextual richness (Pagliarini and Silva, 2007; Wang, 1999), an unsystematic portrayal of scientific methodologies and experimentation (Simsek, 2009), and a restricted representation of scientists' diversity (Pagliarini and Silva, 2007). These limitations collectively impede the full realization of the educational potential inherent in the HOS.

2.3 History of science in Chinese geography education: a unique context

The integration of the HOS holds significant pedagogical value within science education; however, its implementation varies considerably across diverse academic disciplines and national curriculum frameworks. As a discipline that bridges the natural sciences and the humanities and social sciences, geography is uniquely positioned. The International Charter for Geography Education defines geography as "the study of human activities and their interactions and relationships with the natural environment, either globally or within a certain region" (International Geographical Union Commission on Geographical Education, 2016).

Consequently, geography curricula encounter specific contexts and challenges regarding the integration of the HOS. Globally, two predominant models characterize geography curricula. The first involves subdisciplinary configurations, as observed in countries such as the United States, France, and Japan, where geography and earth sciences are incorporated separately into social studies and science curricula. This model tends to confine the presentation of the HOS within the boundaries of distinct subject areas, which, for integrated geography courses, can reinforce disciplinary compartmentalization and limit the extent to which the nature of science is substantively addressed. The second model, represented by integrated configurations in countries such as the

United Kingdom, Finland, and Singapore, consolidates elements of geography, earth sciences, environmental sciences, and civic education into a single curricular framework. Such integration facilitates the removal of disciplinary boundaries, fosters the holistic connection between physical and human geography, and creates greater opportunities for embedding the HOS. This divergence stems primarily from varied national interpretations of the disciplinary value of geography and the unique historical trajectories of the development of the geography curriculum in each country (van der Schee et al., 2024; Wang et al., 2023).

In China, basic education follows an integrated curriculum structure. Middle school geography (grades 7 and 8) primarily emphasizes regional geography and includes two key modules: "understanding the globe" and "understanding regions." Conversely, high school geography (grades 10, 11, and 12) focuses on systematic geography, with modules dedicated to physical geography, human geography, and regional geography. Despite the inclusion of certain social science content, the inherent integrative nature of the Chinese geography curriculum provides ample opportunities for the incorporation of historical narratives from science.

Empirical evidence from pertinent studies indicates a discernible trend toward the enhanced integration of the HOS within Chinese geography textbooks. Furthermore, the modes of content presentation have evolved progressively from simple textual descriptions to more varied formats, including combinations of graphics and text as well as case studies (Liu, 2019; Liang et al., 2023). Conversely, scholarly investigations suggest that in comparison to HOS in traditional science disciplines such as physics and chemistry, HOS content in geography textbooks remains relatively limited and is often characterized by a singular mode of presentation and a paucity of inquiry-based activities (Heering and Höttecke, 2014). Moreover, the majority of relevant research has concentrated on the senior high school level, leading to a comparative scarcity of empirical studies that systematically assess HOS content in junior high school geography textbooks.

Propelled by the ongoing wave of curriculum reform, the Ministry of Education (MOE) of the People's Republic of China issued the Geography Curriculum Standards for General High Schools in 2017 and the Geography Curriculum Standards for Compulsory Education in 2022. These standards propose that core literacies, including a harmonious view of human–environment interaction, integrated thinking, regional cognition, and practical geographic competence, should guide the reform of geography curricula, textbooks, and pedagogical practices (Ministry of Education of the People's Republic of China, 2022).

The core competencies of geography demonstrate a high degree of compatibility with SL in terms of both underlying concepts and overarching objectives. For instance, a harmonious view of human–environment interactions includes principles of scientific ethics and sustainable development. Similarly, practical geographic competence emphasizes the crucial processes of observation, experimentation, and verification inherent in scientific inquiry. Consequently, the cultivation of SL has been reinforced in the latest revisions of geography textbooks. This development occurs at a pivotal juncture and provides a valuable opportunity to critically examine how the newly revised textbooks operationalize educational objectives by integrating the HOS.

3 Materials and methods

This study uses a content analysis methodology to investigate the arrangement and distribution of HOS content within geography textbooks. Content analysis is a research technique that systematically condenses extensive textual data into concise and well-defined content categories based on explicit coding rules (Berg and Lune, 2017). The research was executed in three distinct phases, as outlined below.

3.1 Study materials

The research sample for this study consists of eight of the ten MOE-approved versions of junior high school geography textbooks as of September 2024. The analysis focuses specifically on the content of the first-semester Grade 7 textbooks. The selection of these materials was guided by the following criteria. (1) Richness of HOS Content: This academic level was chosen because its curriculum standards mandate content with significant potential for HOS integration. A preliminary review by our research team confirmed that the "understanding the globe" module, which covers topics such as the cosmic environment, the Earth's movements, and the Earth's surface systems from a global perspective, provides a systematic context for incorporating HOS and aligns well with the objectives of this study. (2) Representativeness and Comparability: The selected textbook versions command a substantial market share and exhibit representative and comparable content structures. Two textbook versions were excluded from the sample: the Shandong Education Press version, due to its content being largely identical to that of the People's Education Press (PEP) version, and the China Cartographic Publishing House version, which was omitted because of its significantly different organizational structure. Detailed information on the final sample is presented in Table 1.

3.2 Analytical framework

To ensure the logical rigor and applicability of the analytical framework for this study, the original framework proposed by Leite (2002) was systematically revised to align with the specific characteristics of Chinese geography textbooks. The key modifications are as follows.

First, the theme "type and organization of historical information" from Leite's framework was deemed to lack sufficient specificity for the discipline of geography. Consequently, this theme was re-conceptualized as "A. Thematic Content of HOS" and aligned with established classifications in the history of geographical science. The dimension "A1 Content Category" was established, which comprised four distinct categories: (a) A1-1 Geographers and Explorers, (b) A1-2 Evolution of Geographic Theories and Ideas, (c) A1-3 Significant Events and Expeditions,

TABLE 1 Basic information on the junior high school geography textbooks considered in this study.

Version	Editor-in-chief	Code
People's education press	Fan Jie	PEP
Guangdong academy of education, Guangdong education publishing house, Guangdong people's press	Wu Zhifeng	YJ
Beijing Ren'ai education institute's popular science press	Chen Shi	KP
Hunan education press	Zhu Xiang, Liu Xinmin	XJ
Shanxi education press	Lin Peiyin	JJ
The commercial press, Star map press	Cai Yunlong	XQ
Beijing academy of educational sciences, Sinomap press	Zhong Zuoci	BJ
Sinomap press, Chinese map publishing house	Duan Yushan	HJ

The HJ version is for the 5–4 school system, and the selected version corresponds to the first book of the sixth grade.

and (d) A1-4 Key Inventions and Publications. Furthermore, to facilitate a nuanced analysis of content origins, the dimension "A2 Content Sources" was introduced, and materials were categorized as domestic, foreign, or mixed domestic and foreign.

Second, to characterize the presentation of historical materials more precisely, Leite's dimension "materials used to present the historical information" was replaced and expanded. This led to the creation of the theme "B. Modes of HOS Presentation," which included two new dimensions: "B2 Positional Context" and "B3 Depth of Integration." This enhancement was intended to improve the framework's targeted applicability for analyzing textbook content.

Third, to capture the pedagogical intentions of historical activities, a new theme titled "D. Epistemological and Cultural Orientations of HOS" was incorporated, building upon the foundational work of Ma and Wan (2017) and Chi et al. (2024). This theme was structured around two subdimensions: "D1 Content Orientation" and "D2 Attitudinal Orientation." The former was further subdivided into three pedagogical aims: D1-1 Disciplinary Knowledge Orientation, D1-2 Humanistic and Values Orientation, and D1-3 Philosophical Thinking Orientation. This analytical dimension is pivotal for elucidating the mechanisms by which geography textbooks attempt to shape students' values and attitudes.

Fourth, three themes from Leite (2002) were omitted due to their irrelevance in the context of contemporary Chinese textbooks. The themes "'correctness and accuracy of historical information" and "internal consistency of the book" were rendered superfluous by the mandatory, rigorous review by the MoE, while "bibliography on the history of science" was excluded due to its general absence from the chosen textbooks.

Finally, the theme "C. Pedagogical Activities Related to HOS," which represented a consolidation and follow-up of Leite's original "learning activities dealing with history of science," was retained without modification.

TABLE 2 Analytical framework and operational definitions of the history of science in geography textbooks.

Theme, dimension and category	Operational definition
A. Thematic content of HOS	
A1 Content category	
A1-1 Geographers and explorers	Content that introduces the biographies, achievements, personal characteristics, or notable anecdotes of geographers and explorers.
A1-2 Evolution of geographic theories and ideas	Content that presents the formulation and resolution of classic geographic problems or the formation and evolution of geographic theories and ideas.
A1-3 Significant events and expeditions	Content describing milestone events or expeditions, past or ongoing, that have had a significant impact on the development of geography.
A1-4 Geoscientific inventions	Content related to classic geographical works, atlases, or major inventions from ancient or modern times.
A2 Content sources	
A2-1 Domestic	Content derived from HOS materials related to China, highlighting the nation's unique position and contributions.
A2-2 Foreign	Content explicitly attributed to other countries, highlighting their contributions to the global history of science.
A2-3 Mixed domestic and foreign	Content that presents a mixed arrangement of scientific achievements from different countries and regions, emphasizing the international nature of science.
B. Modes of HOS presentation	
B1 Presentation format	
B1-1 Textual narration	HOS content presented exclusively through written text.
B1-2 Pictorial representation	HOS content conveyed solely through images, such as portraits, photographs, or diagrams.
B1-3 Text-Image integration	HOS content delivered through a combination of both textual descriptions and visual elements.
B2 Positional context	
B2-1 Introductory context	HOS content that appears in the beginning of a chapter or a section, typically to create a learning scenario or pose an introductory problem.
B2-2 Main body integration	HOS content interwoven directly into the main narrative of the chapter, used to explain the discipline's knowledge through historical accounts of scientists, events, or discoveries.
B2-3 Supplementary reading	HOS content featured in designated reading sections (e.g., "Extended Reading," "Think and Learn," "Case Study"), presented as ancillary material for enrichment.
B2-4 Exercises and assessments	HOS content embedded within homework assignments, review questions, or other assessment tasks.
B3 Depth of integration	
B3-1 Ornamental integration	HOS content that appears as isolated elements, such as portraits of geographers or standalone images of historical events, serving primarily a decorative or "add-on" function.
B3-2 Supplementary integration	HOS content presented as textual or pictorial material that aids in understanding a geographer's life, a geographic concept, or a historical event such that its removal would not disrupt the core conceptual flow of the main text.

(Continued)

TABLE 2 (Continued)

Theme, dimension and category	Operational definition
B3-3 Intrinsic integration	HOS content that is fundamentally woven into the pedagogical approach, often involving a reconstruction of a historical event or phenomenon to present knowledge through a genetic approach, tailored to students' cognitive needs and classroom instruction.
C. Pedagogical activities related to HOS	
C1 Activity status	
C1-1 Mandatory	The activity is designated as a mandatory component of the curriculum that all students are required to complete.
C1-2 Optional	The activity is presented as a voluntary task that students may undertake based on their personal interest for enrichment purposes.
C2 Activity level	
C2-1 Standard	The activity's purpose and level of cognitive difficulty are not explicitly stated, implying that it is consistent with the baseline learning objectives.
C2-2 Deepening	The activity is explicitly designed to foster deeper learning or promote advanced understanding beyond the core curricular requirements.
C3 Activity approach	
C3-1 Guided reading	The activity directs students to read HOS-related texts without requiring a subsequent discussion or a practical application.
C3-2 Inquiry-Based discussion	The activity requires students to analyze or perform calculations on historical data and phenomena, followed by a structured discussion of key scientific issues.
C3-3 Simulation experiment	The activity involves a reenactment or a simulation of a significant historical experiment or discovery. This method is supported by educational research for its capacity to foster conceptual understanding.
C3-4 Extracurricular extension	The activity requires students to consult resources or books on the history of science related to the textbook, etc.
C3-5 Scientific writing	The assignment requires students to compose a scientific text (e.g., an argumentative essay or a summary report) analyzing events or developments from the history of science.
C3-6 Summary evaluation	This activity motivates students to engage in reasoned evaluation or critical thinking about geoscientists and their work, thereby mobilizing higher-order thinking skills.
D. Epistemological and cultural orientations of HOS	
D1 Content orientation	
D1-1 Discipline-specific knowledge orientation	HOS content is primarily used to support the learning of geographic subject matter. It serves to introduce key concepts, explain the origins and development of knowledge, enhance conceptual understanding, and cultivate thinking about this discipline. The use of history to make subject matter more comprehensible is a well-established pedagogical strategy.
D1-2 Humanistic and values orientation	HOS content focuses on the humanistic aspects of science. It presents the difficulties and complexities of scientific discovery to showcase the personal dedication and ethical qualities of scientists, with the aim of fostering patriotism and a sense of social responsibility.
D1-3 Philosophical thinking orientation	HOS content is specifically selected for its capacity to provide valuable insights that cultivate philosophical modes of thought. It is intended to help students develop abilities such as dialectical and critical thinking, seeing interconnectedness of varied subjects, and fostering an innovative mindset.
D2 Attitudinal orientation	
D2-1 Positive	HOS content is presented from a consistently positive and affirmative perspective, emphasizing successes, achievements, and the virtuous attributes of scientists.
D2-2 Neutral	HOS content is presented in an impartial and multifaceted manner. It provides a depiction that considers various sides of an issue, thereby avoiding discernible bias.
D2-3 Negative	HOS content is presented from a predominantly negative or critical perspective, often focusing on the failures, flaws, conflicts, or adverse consequences associated with historical events or figures.

(Continued)

TABLE 2 (Continued)

Category D2-3, "Supplementary Reading", exhibits varied nomenclature across textbook editions and is typically represented by supplementary extended reading or case study materials distinct from the core text and assigned exercises.

As a result of the aforementioned adjustments, an initial analytical framework comprising four themes was developed. To further refine and validate this framework, a research group consisting of five geography education researchers was established. This group engaged in multiple iterations of review and revision, leading to the finalized framework presented in Table 2.

The definitive framework is composed of four interconnected and mutually influential themes, which are further articulated through ten analytical dimensions. The theme "A. Thematic Content of HOS" is foundational and specifies the quantity, type, and sources of historical content. "B. Modes of HOS Presentation" reflects the degree of integration between HOS and the main textbook narrative and influences students' exposure to and perception of this content. "C. Pedagogical Activities Related to HOS" highlights the learning opportunities created for students through historical materials. Finally, "D. Epistemological and Cultural Orientations of HOS" addresses the pedagogical values embedded in the content and the neutrality of the attitudes conveyed.

3.3 Coding process

To systematically analyze the characteristics and variations in the representation of HOS within geography textbooks, this study used a standardized coding procedure that comprised the following three phases:

(1) Text preprocessing and extracting content units for analysis: Initially, all eight geography textbooks were thoroughly reviewed to identify relevant content. For textual materials, paragraphs pertaining to HOS located under major headings were designated the primary units of analysis. These units

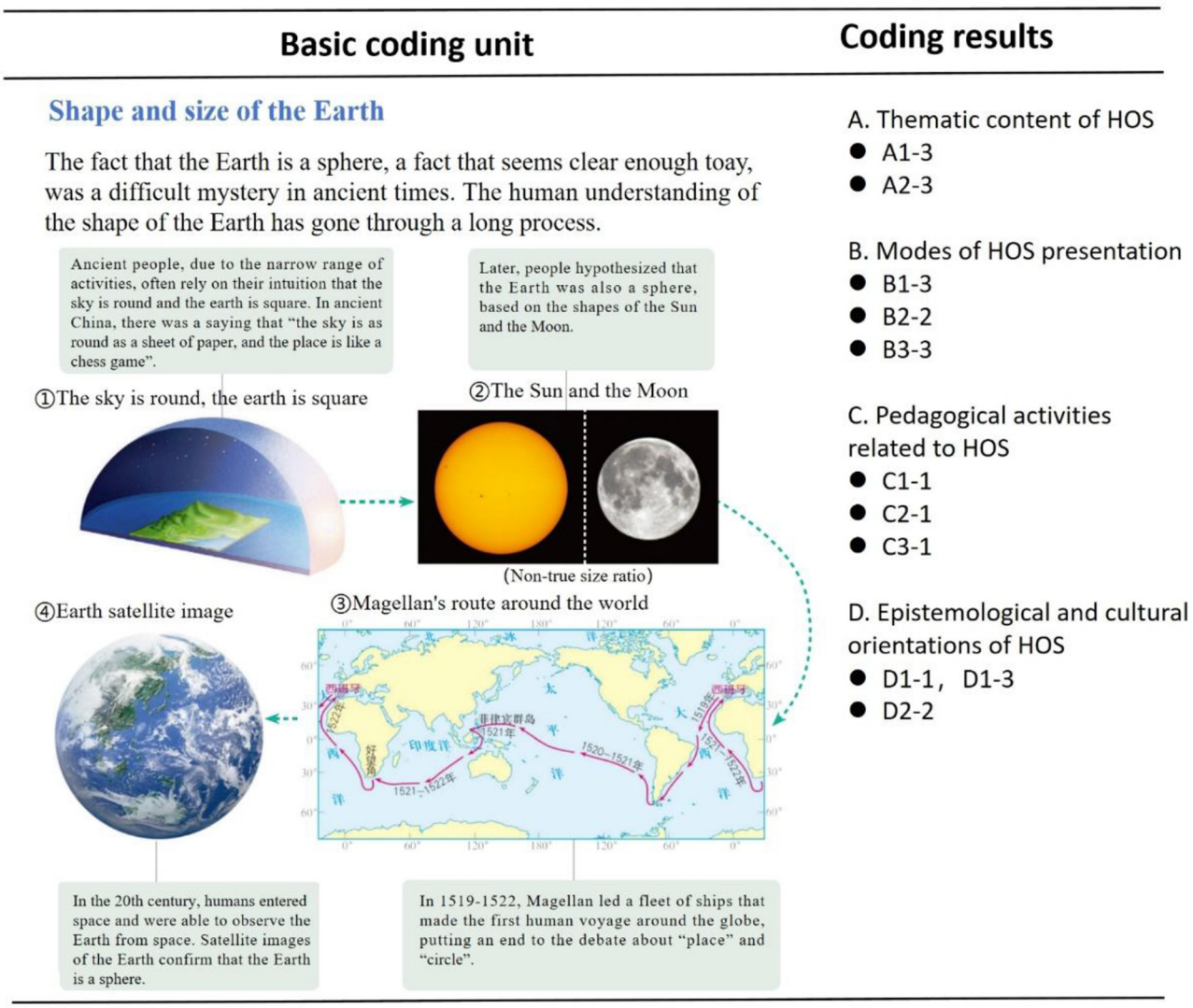

FIGURE 1
Sample content on the history of science in the PEP version of a 7th grade geography textbook (p. 11).

included multiple paragraphs or distinct sections, such as "Extended Readings." For pictorial content, the combination of an image and its corresponding caption constituted the minimal unit of analysis. Subsequently, all identified content related to HOS was systematically extracted for coding.

(2) Coding the HOS: A coding team was formed by one professor and two PhD students. The coding principles and methods were discussed before coding, 10% of the samples were used for precoding in the first round, and full coding was performed after a consistency test was passed. Effective communication was maintained during the coding process, and a group consultation was organized to form a consensus for inconsistent codes.

(3) Coding guidelines: The following principles were followed during the coding process: or analytical units that exhibited features corresponding to multiple categories, a primary code was assigned based on the most salient characteristic, which determined the dominant category. Due to the complexity of the textbook materials, the category "Pedagogical Activities Related to HOS" was observed to be highly diverse in its content orientation. Consequently, this specific dimension permitted the assignment of multiple codes (i.e., it was counted repeatedly), whereas all other dimensions were restricted to a single code per unit of analysis.

For example, content in the PEP version of the geography textbook is coded as follows (see Figure 1). Although the case study presents numerous historical events and figures, its function is primarily supplementary, and the core pedagogical objective is to facilitate students' understanding of the historical process of human inquiry into the Earth. This case is situated within the main body of the text following a B1-3 text-image integration format. Furthermore, historical materials from various periods are pedagogically reconstructed to align with students' learning

TABLE 3 Comparison and analysis of the total number of instances and content categorization of HOS in eight versions of geography textbooks.

Version	A1-1 geographers and explorers, *n* (%)	A1-2 evolution of geographic theories and ideas, *n* (%)	A1-3 significant events and expeditions, *n* (%)	A1-4 geoscientific inventions, *n* (%)	Total, (*n*)
PEP	2 (9.1)	5 (22.7)	12 (54.5)	3 (13.6)	22
KP	4 (14.8)	5 (18.5)	13 (48.1)	5 (18.5)	27
XJ	1 (5)	6 (30)	10 (50)	3 (15)	20
XQ	4 (16.7)	4 (16.7)	9 (37.5)	7 (29.2)	24
YJ	3 (10.7)	6 (21.4)	13 (46.4)	6 (21.4)	28
BJ	4 (12.1)	5 (15.2)	15 (45.5)	9 (27.3)	33
JJ	0 (0)	9 (36)	9 (36)	7 (28)	25
HJ	7 (28)	6 (24)	8 (32)	4 (16)	25
Mean	3.1 (12.1)	5.8 (23.1)	11.1 (43.8)	5.5 (21.1)	25.5

patterns, justifying the coding of B3-3 Intrinsic Integration for B3 Depth of Integration and B2-2 Main Body Integration for B2 Positional Context. Consequently, classifications are established for A1 Content Category as A1-3 Significant Events and Expeditions and A2 Content Sources as A2-3 Mixed Domestic and Foreign. In terms of pedagogical activities, this content is part of the main text that all students are required to read, which corresponds to a C1 Activity status of C1-1 Mandatory. With regard to the dimension D1 content orientation, this material serves a dual purpose: it not only aids in the comprehension of scientific knowledge, such as the Earth's shape and its discovery process (D1-1 Disciplinary Knowledge Orientation) but also guides students to cultivate a scientific worldview based on the concepts of connection and development (D1-3 Philosophical Thinking Orientation). Finally, given its impartial presentation of historical facts, dimension D2 Attitudinal Orientation is coded as D2-2 Neutral.

4 Results

4.1 Statistical analysis and comparison of the thematic content of HOS

Table 3 presents the total number of instances and the distribution of content related to HOS across eight different versions of junior high school geography textbooks. Overall, a significant variation in the total volume of HOS content is observed among the textbook versions. The BJ version contains the highest number of instances ($n = 33$), followed by the YJ ($n = 28$) and KP ($n = 27$) versions. In contrast, the XJ ($n = 20$) and PEP ($n = 22$) versions feature comparatively lower counts.

A high degree of consistency with respect to content categorization is observed across the different textbook versions. The category "A1-3 Significant Events and Expeditions" accounts for the largest proportion, with an average share of 43.8%. Thus, geography textbooks tend to structure their HOS content around the historical process of human spatial exploration. Following this, each of the categories "A1-2 Evolution of Geographic Theories and Ideas" and "A1-4 Geoscientific inventions" represents approximately 20% of content. In contrast, the category "A1-1 Geographers and Explorers" accounts for the smallest share.

In terms of content sources, textbook versions can be broadly classified into three distinct types (see Figure 2). The first is "locally oriented," which emphasizes the transmission of indigenous scientific culture. For instance, in the BJ and XQ versions, domestic HOS materials constitute more than 50% of the total, reflecting a focus on fostering national identity. The second type is "internationally oriented," which highlights a global perspective. The JJ and HJ versions exemplify this, with foreign HOS materials exceeding 50% and the prioritization of the cultivation of global awareness. The third type is "balanced," which is characterized by a relatively even distribution of domestic and foreign materials. Versions such as PEP, KP, XJ, and YJ belong to this category and aim to provide a comprehensive understanding of the development of geography by incorporating diverse sources.

Further qualitative analysis reveals that the selection of HOS content across all eight textbook versions is generally consistent with the requirements of the national geography curriculum standards, emphasizing both foundational knowledge and contemporary relevance (see Figure 3). On the one hand, the textbooks feature a wide selection of classic and fundamental HOS topics. For instance, narratives such as "the process of discovering the Earth's shape," "the geocentric and heliocentric models," and "Wegener and the theory of continental drift" are widely adopted. These topics, typically organized under themes such as "the Earth's Cosmic Environment," "the Earth's Motion," and "the Earth's Surface Layers," help students trace the origins of key scientific concepts and build a foundational scientific understanding. On the other hand, the textbooks actively incorporate contemporary research advancements, including issues such as space exploration, manned deep-sea submersibles, climate change, and scientific expeditions. This approach vividly presents the latest scientific and technological achievements, ensuring that HOS content remains current and relevant.

Despite this overall consistency, variations in content selection are evident among the different versions. As shown in Table 3, most versions pay limited attention to the category "A1-1 Geographers and Explorers," with a notable underrepresentation of female scientists. The HJ version performs best in this category ($n =$

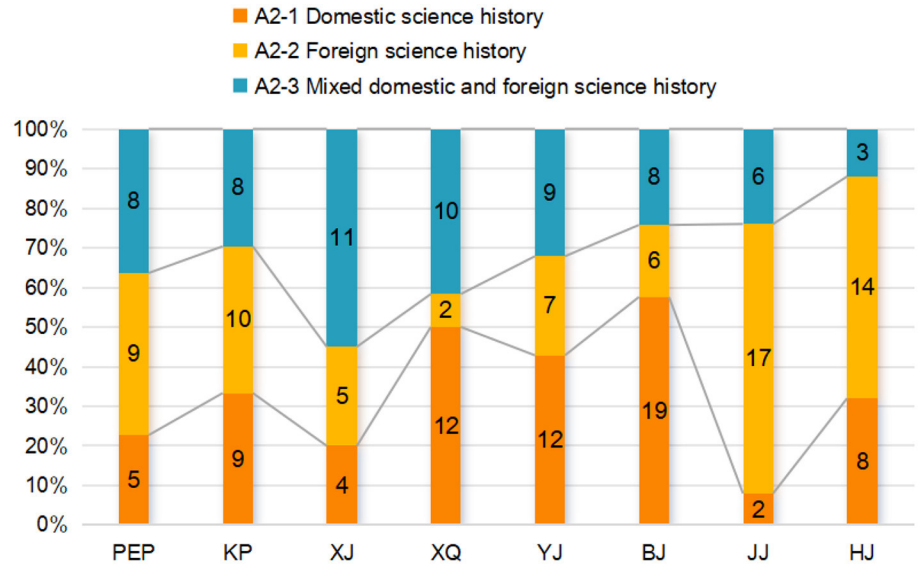

FIGURE 2
Content sources of HOS in eight versions of geography textbooks.

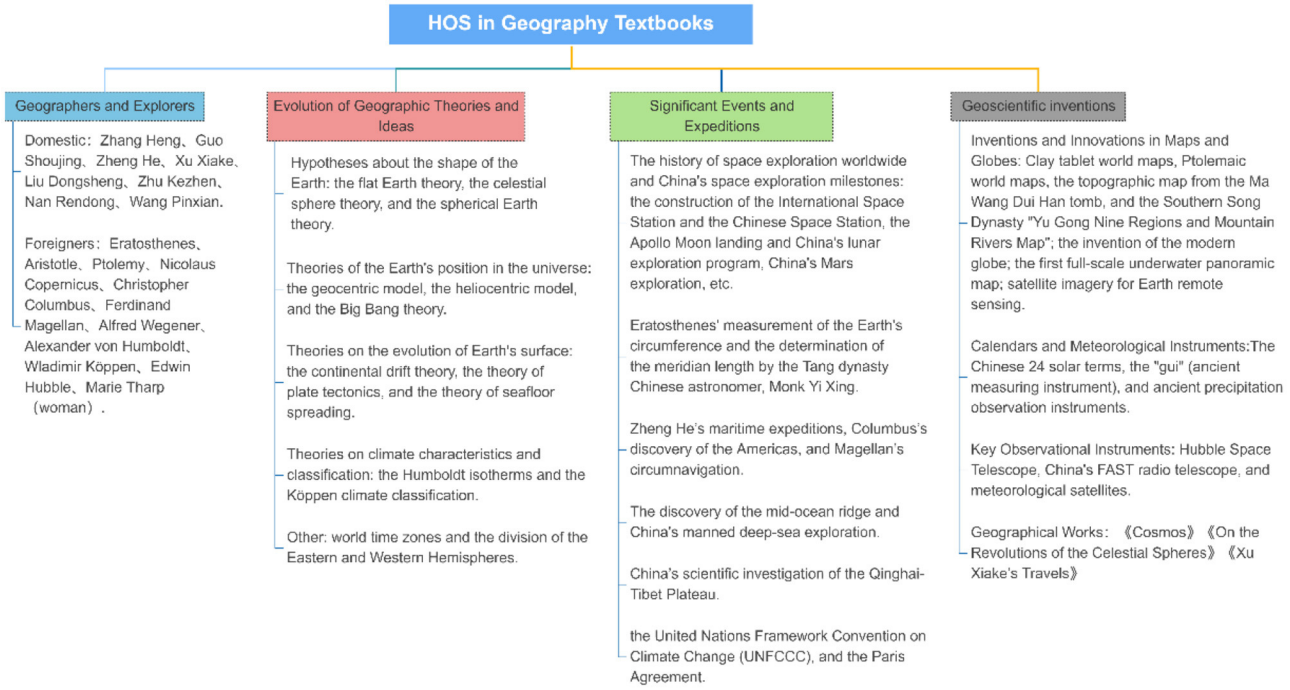

FIGURE 3
Thematic mapping of HOS content in eight versions of geography textbooks.

7, 28%), featuring not only pioneers such as Wegener but also other significant scientists such as Xu Xiake, Liu Tungsheng, and Wladimir Köppen. Notably, Marie Tharp, mentioned in this version, is the only female scientist presented across all the examined textbooks. In contrast, the JJ version does not directly feature any content on geographers; instead, it has a relatively high proportion of content in the "A1-2 Evolution of Geographic Theories and Ideas" category (n = 9, 36%) and emphasizes the developmental trajectory of theories and academic shifts. The PEP version is particularly strong in "A1-3 Significant Events and

TABLE 4 Comparison and analysis of modes of HOS presentation in eight versions of junior high school geography textbooks.

Dimension	Category	PEP	KP	XJ	XQ	YJ	BJ	JJ	HJ
B1 Presentation Format	B1-1 Textual Narration, *n* (%)	5 (22.7)	4 (14.8)	10 (50.0)	1 (4.2)	4 (14.3)	11 (33.3)	6 (24.0)	3 (12.0)
	B1-2 Pictorial Representation, *n* (%)	1 (4.5)	0 (0.0)	0 (0.0)	1 (4.2)	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.0)
	B1-3 Text-Image Integration, *n* (%)	16 (72.7)	23 (85.2)	10 (50.0)	22 (91.7)	24 (85.7)	22 (66.7)	19 (76.0)	21 (84.0)
B2 Positional Context	B2-1 Introductory Context, *n* (%)	4 (18.2)	4 (14.8)	5 (25.0)	6 (25.0)	6 (21.4)	8 (24.2)	0 (0.0)	4 (16.0)
	B2-2 Main Body Integration, *n* (%)	9 (40.9)	4 (14.8)	4 (20.0)	9 (37.5)	9 (32.1)	11 (33.3)	13 (52.0)	6 (24.0)
	B2-3 Supplementary Reading, *n* (%)	9 (40.9)	16 (59.3)	7 (35.0)	5 (20.8)	12 (42.9)	9 (27.3)	12 (48.0)	12 (48.0)
	B2-4 Exercises and Assessments, *n* (%)	0 (0.0)	3 (11.1)	4 (20.0)	3 (12.5)	1 (3.6)	5 (15.2)	0 (0.0)	3 (12.0)
B3 Depth of Integration	B3-1 Ornamental Integration, *n* (%)	3 (13.6)	1 (3.7)	0 (0.0)	1 (4.2)	1 (3.6)	1 (3.0)	0 (0.0)	4 (16.0)
	B3-2 Supplementary Integration	10 (45.5)	12 (44.4)	8 (40.0)	15 (62.5)	14 (50.0)	15 (45.5)	10 (40.0)	9 (36.0)
	B3-3 Intrinsic Integration	9 (40.9)	14 (51.9)	12 (60.0)	8 (33.3)	13 (46.4)	17 (51.5)	15 (60.0)	12 (48.0)

Expeditions," while the XQ version has a larger amount of content in "A1-4 Geoscientific inventions" and focuses on important studies, atlases, and research activities.

4.2 Analysis and comparison of the modes of HOS presentation

The way the HOS is presented critically influences students' understanding of the NOS. According to the cognitive theory of multimedia learning by Mayer (2005), a combination of visual and linguistic elements facilitates more effective information processing. As indicated in Table 4, text-image integration (B1-3) is the most dominant presentation format and accounts for more than 60% of HOS content in all versions except the XJ version. This integrated approach allows for an intuitive and vivid depiction of geographers' portraits and historical events, significantly enhancing the reading experience. Textual narration (B1-1) is the second most common format, emphasizing theoretical depth and logical coherence. In contrast, pictorial representation (B1-2) is the least utilized format, typically serving a supplementary illustrative purpose.

The placement of HOS content within textbooks reflects the editors' pedagogical intentions and considerations of learning logic. As shown in Table 4, presenting HOS content via main body integration (B2-2) and supplementary reading (B2-3) is the most common strategy adopted across all versions. The introductory context (B2-1) approach is used less frequently, and the use of the exercises and assessments (B2-4) strategy is observed least frequently. A closer examination of inter-version differences reveals that the XJ (n = 5, 25.0%), XQ (n = 6, 25.0%), and BJ (n = 8, 24.2%) versions use the introductory context more frequently. This suggests an emphasis on stimulating learning interest and promoting active thinking through historical scenarios. Conversely, the PEP (n = 9, 40.9%) and JJ (n = 13, 52.0%) versions are notable for embedding HOS content directly within the main text, which is a method that strengthens the connection between historical narratives and core subject matter, thereby enhancing learning coherence and the systematic presentation of materials. The KP (n = 16, 59.3%), YJ (n = 12, 42.9%), and HJ (n = 12, 48.0%) versions, following yet another strategy, tend to feature HOS content predominantly in the supplementary reading sections. The latter are designed with diverse reading and inquiry tasks to broaden students' knowledge horizons and cultivate critical thinking skills. The BJ version demonstrates the greatest diversity in positional context, enriching the channels through which students can access the HOS content.

The depth of integration reflects the extent to which HOS content is woven into the textbook's fabric. A higher degree often corresponds to greater heuristic and exploratory potential. Table 4 shows that the overall depth of integration across all versions is relatively high, dominated by intrinsic integration (B3-3) and supplementary integration (B3-2), while ornamental integration (B3-1) is used sparingly. Hence, the use of HOS in geography textbooks is generally flexible and capable of meeting diverse student learning needs. Further analysis indicates that the XJ (n = 12, 60%) and JJ (n = 15, 60%) versions most frequently rely on intrinsic integration, demonstrating excellence in the natural fusion of historical and geographical content in a manner that aligns with students' cognitive patterns. In contrast, the HJ version features a relatively greater proportion of ornamental integration (n = 4, 16%), which primarily involves presenting isolated images of scientists or historical events that can be omitted without disrupting the overall narrative flow.

4.3 Analysis and comparison of pedagogical activities related to HOS

The design of HOS-related pedagogical activities reflects textbook editors' understanding of instructional objectives for the history of geography and profoundly influences students' learning approaches. As shown in Table 5, HOS activities across all eight textbook versions are predominantly optional (C1-2) in status, with this category accounting for over 50% in all versions and even exceeding 80% in some. This indicates a widespread pedagogical trend in current geography textbooks to encourage student autonomy in learning and exploration, fostering students' active engagement in the HOS learning process.

TABLE 5 Comparison and analysis of pedagogical activities related to HOS in eight versions of junior high school geography textbooks.

Dimension	Category	PEP	KP	XJ	XQ	YJ	BJ	JJ	HJ
C1 Activity Status	C1-1 Mandatory, *n* (%)	10 (45.5)	9 (33.3)	4 (20.0)	8 (33.3)	7 (25.0)	11 (33.3)	11 (44.0)	6 (24.0%)
	C1-2 Optional, *n* (%)	12 (54.5)	18 (66.7)	16 (80.0)	16 (66.7)	21 (75.0)	22 (66.7)	14 (56.0)	19 (76.0%)
C2 Activity Level	C2-1 Standard, *n* (%)	10 (45.5)	18 (66.7)	9 (45.0)	9 (37.5)	15 (53.6)	13 (39.4)	5 (20.0)	12 (48.0%)
	C2-2 Deepening, *n* (%)	12 (54.5)	9 (33.3)	11 (55.0)	15 (62.5)	13 (46.4%)	20 (60.6)	20 (80.0)	13(52.0)
C3 Activity Approach	C3-1 Guided Reading, *n* (%)	19 (86.4)	20 (74.1)	11 (55.0)	17 (70.8)	19 (67.9%)	22 (33.3)	22 (88.0)	18 (72.0)
	C3-2 Inquiry-Based Discussion, *n* (%)	2 (9.1)	4 (14.8)	6 (30.0)	4 (16.7)	4 (14.3%)	9 (33.3)	0 (0.0)	4 (16.0)
	C3-3 Simulation Experiment, *n* (%)	1 (4.5)	1 (3.7)	0 (0.0)	0 (0.0)	0 (0.0%)	1 (33.3)	0 (0.0)	2 (8.0)
	C3-4 Extracurricular Extension, *n* (%)	0 (0.0)	0 (0.0)	2 (10.0)	1 (4.2)	5 (17.9)	1 (33.3)	1 (4.0)	1 (4.0)
	C3-5 Scientific Writing, *n* (%)	0 (0.0)	1 (3.7)	1 (5.0)	2 (8.3)	0 (0.0)	0 (33.3)	2 (8.0)	0 (0.0)
	C3-6 Summary Evaluation, *n* (%)	0 (0.0)	1 (3.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (33.3)	0 (0.0)	0 (0.0)

With regard to the activity level, most versions exhibit a relatively balanced distribution between standard (C2-1) and deepening (C2-2) activities, although notable differences exist. For instance, the KP version's HOS content is primarily composed of standard-level activities ($n = 18$, 66.7%) supplemented by only a few deepening activities. This approach emphasizes the use of HOS as a contextual scaffold for knowledge acquisition. In contrast, the JJ ($n = 20$, 80.0%), BJ ($n = 20$, 60.6%), and XQ ($n = 15$, 62.5%) versions more frequently present deepening activities and design inquiry-based tasks to develop students' higher-order thinking skills.

An analysis of the approach toward activities reveals that nearly all textbook versions center on guided reading (C3-1), a cognitive activity that prioritizes the learning of foundational knowledge through textual engagement with HOS. This is most evident in the PEP ($n = 19$, 86.4%), JJ ($n = 22$, 88.0%—Correction based on calculation), and KP (n=20, 74.1%) versions. Furthermore, different versions incorporate interactive activities such as inquiry-based discussion (C3-2). Such activities, which involve analyzing scientific events or simulating scientists' research processes, aim to promote critical thinking and deeper understanding. This approach is notably present in the XJ ($n = 6$, 30%) and BJ ($n = 9$, 27.3%—correction based on calculation) versions. Other activity types, such as scientific writing (C3-5) and summary evaluation (C3-6), appear only sparsely in a few versions. With regard to the diversity of activities, the KP and HJ versions offer the richest variety of learning activities, demonstrating a progressive and open-ended pedagogical design that values not only inquiry-based discussions but also extracurricular extensions and scientific writing. Conversely, learning activities in versions such as PEP, YJ, and JJ are relatively monolithic, indicating potential for further development.

4.4 Analysis and comparison of epistemological and cultural orientations of HOS

An analysis of content orientations reveals that the disciplinary knowledge orientation (D1-1) is unequivocally the most prominent, constituting over 45% of HOS content across all examined textbook versions (Table 6). This emphasis aligns seamlessly with the pedagogical objectives of the junior high school geography curriculum, which leverages HOS to stimulate learning interest, facilitate conceptual understanding, and cultivate analytical skills, ultimately guiding students toward a solid grasp of core geographic knowledge. Within this shared orientation, however, distinct pedagogical strategies emerge. The JJ version, for instance, enhances content accessibility and appeal by incorporating dedicated reading sections featuring engaging narratives such as "The Earth in the Eyes of Aristotle" and "Around the World in Eighty Days" to foster a passion for reading. Following a different approach, the BJ version prioritizes the integration of classic Chinese geography texts, including excerpts from Yi·Xici, the Book of Han Treatise on Geography, and Huainanzi Treatise on Topography. This approach serves to elucidate the historical lineage of key geographic concepts, thereby facilitating students' cognitive transition from perceptual acquaintance to rational comprehension.

With regard to the humanistic and values orientation (D1-2), all textbook versions demonstrate a commitment to cultivating both national sentiment and a scientific ethos. Through narratives detailing the endeavors of scientists in exploring the natural world and serving society, these textbooks construct an image of the scientist that aims to instill a sense of social responsibility and cultural identity in students. The HJ version exemplifies this by actively integrating elements of exceptional traditional Chinese culture, such as the "24 Solar Terms," and by showcasing the dedication and spirit of eminent geographers such as Liu Tungsheng and Zhu Kezhen, thereby fostering a sense of affinity for and reverence toward these figures.

Conversely, the philosophical thinking orientation (D1-3) receives comparatively little attention. While most textbooks utilize HOS materials to some extent, primarily to foster interconnected developmental and practical innovative thinking, their efforts are generally limited. These activities guide students toward a more profound understanding of geographic phenomena and principles. Nevertheless, it is evident that the integration of a philosophical thinking orientation within HOS content remains an area with considerable potential for future development.

TABLE 6 Comparison and analysis of pedagogical activities related to hos in eight versions of junior high school geography textbooks.

Dimension	Category	PEP	KP	XJ	XQ	YJ	BJ	JJ	HJ
D1 Content orientation	D1-1 Discipline-specific Knowledge Orientation, *n* (%)	19 (46.3)	24 (49.0)	20 (60.6)	22 (61.1)	28 (62.2)	33 (58.9)	24 (58.5)	25 (64.1)
	D1-2 Humanistic and Values Orientation, *n* (%)	9 (22.0)	15 (30.6)	9 (27.3)	13 (36.1)	13 (28.9)	13 (23.2)	5 (12.2)	8 (20.5)
	D1-3 Philosophical Thinking Orientation, *n* (%)	13 (31.7)	10 (20.4)	4 (12.1)	1 (2.8)	4 (8.9)	10 (17.9)	12 (29.3)	6 (15.4)

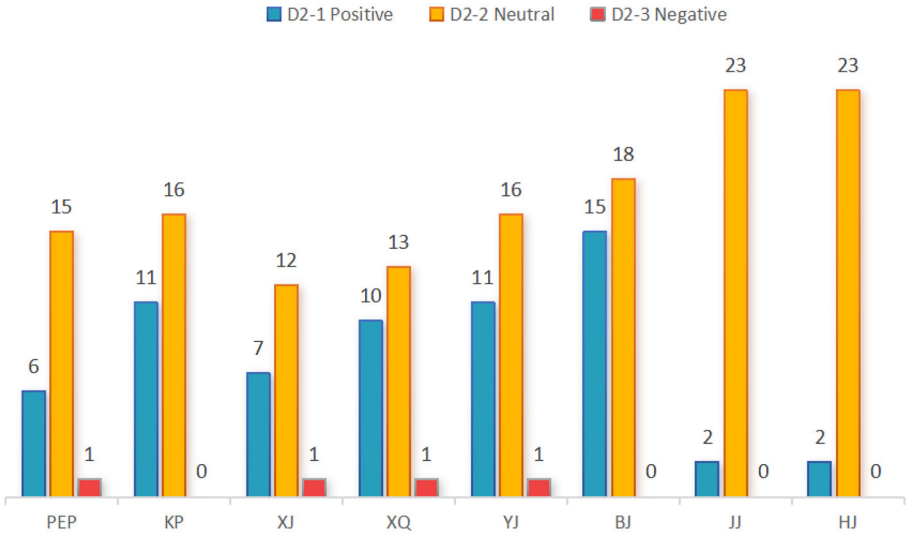

FIGURE 4
Attitudinal orientations of HOS content in eight versions of geography textbooks.

As illustrated in Figure 4, the attitudinal orientation of HOS content is predominantly neutral (D2-2) or positive (D2-1), with the negative (D2-3) orientation occurring notably infrequently. This general trend underscores a curricular emphasis on the objectivity inherent in the natural sciences. A more granular analysis, however, uncovers divergent approaches among the publishers. The JJ and HJ versions, for instance, adopt discernibly more neutral stances. These textbooks prioritize an authentic and objective portrayal of the development of geographical science and its societal context. By carefully balancing expressions of national identity with a commitment to scientific integrity, they maintain a consistently impartial tone. In stark contrast, the remaining versions display a more pronounced positive orientation. The latter texts frequently highlight exemplary aspects of traditional Chinese culture, the arduous struggles of its people, and national achievements in science and technology. The narratives are often infused with laudatory and affirmative language that is strategically used to cultivate a sense of national pride among students. Beyond this dichotomy, some versions also integrate discussions of contemporary challenges facing both the discipline of geography and society at large. This inclusion serves a clear pedagogical purpose to motivate students to study geography and contribute to national development, thereby fostering a heightened sense of civic responsibility.

5 Discussion and conclusion

This study established an analytical framework for the history of science in geography textbooks and conducted a comparative analysis of its representation in eight editions of Chinese junior high school geography textbooks. The analysis yielded four key conclusions. (A) Insufficient volume and unbalanced content categories: The overall amount of HOS content in Chinese junior high school geography textbooks is limited. A notable imbalance exists among content categories: "Significant Events and Expeditions" (A1-3) is the most represented category, whereas "Geographers and Explorers" (A1-1) is consistently underrepresented. While the content sources reflect both foundational and contemporary topics, their distribution across textbooks is uneven. This finding suggests a potential gap in presenting the human dimension of scientific discovery. This point has also been noted in studies of science textbooks in other contexts, which often note an overemphasis on established facts rather than the process and people behind them (e.g., McComas, 2008). (B) Partial and superficial presentation and integration: HOS content is predominantly delivered via "text-image integration" (B1-3) and is typically situated within the "main body" (B2-2) of the text or as "supplementary reading" (B2-3) to enhance the logical coherence and breadth of geographic knowledge. However,

its use in "introductory contexts" (B2-1) and "exercises and assessments" (B2-4) is markedly less frequent. Regarding the depth of integration, most textbooks favor "Intrinsic Integration" (B3-3) or "Supplementary Integration" (B3-2). While these approaches provide some heuristic and exploratory value, the general mode of presentation remains relatively surface-level. (C) Limited diversity in pedagogical activities: The learning activities related to HOS are predominantly optional (C1-2) rather than mandatory. In terms of cognitive demand, most textbooks maintain a reasonable balance between "standard" (C2-1) and "deepening" (C2-2) activities. Nevertheless, the range of approaches to activities is narrow, and textbooks rely heavily on "guided reading" (C3-1) and "inquiry-based discussion" (C3-2). This indicates a need to diversify pedagogical strategies to include more hands-on or constructive tasks, such as "simulation experiments" (C3-3) or "scientific writing" (C3-5), to foster a more active engagement with the scientific process. (D) Homogeneous value orientation: The epistemological orientation of HOS content is relatively singular. The "disciplinary knowledge orientation" (D1-1) is the most prominent, which is consistent with the primary goal of content delivery in junior high school but may not sufficiently foster the critical and innovative thinking skills emphasized in modern science education standards. The attitudinal orientation is mainly "positive" (D2-1) or "neutral" (D2-2). This balanced approach effectively conveys both the national contributions and the universal nature of science; however, a more nuanced inclusion of the complexities and debates within HOS could further enrich students' understanding.

5.1 Enhancing the integration of the history of science in geography textbooks

As established in the preceding analysis, the volume of HOS content in Chinese junior high school geography textbooks is notably limited. While this scarcity is a recognized issue in other science disciplines, such as physics (Lin et al., 2023) and chemistry (Niaz and Rodríguez, 2000), its manifestation in geography is particularly conspicuous and appears to stem from two challenges.

First, the current national curriculum standards for geography pay limited attention to HOS. They lack clear guidelines concerning the dimensions, directions, and key points of content selection, which results in a perfunctory and superficial integration of HOS in textbooks. Second, a general lack of expertise in the philosophy and HOS among textbook editors often contributes to a monolithic representation of HOS, leading to a conservative approach in both the selection and the presentation of material.

Therefore, this study proposes two key recommendations. At the level of the national curriculum standards, it is recommended that explicit objectives for HOS coverage be established. Furthermore, a dedicated framework for HOS integration should be developed to provide actionable guidelines for textbook authors and editors. Concurrently, the composition of textbooks' editorial and review teams should be enhanced by actively recruiting experts with backgrounds in the history and philosophy of science. Their involvement is crucial for raising the quality and the pedagogical effectiveness of HOS integration in future textbook editions.

5.2 Diversifying the content on the history of science in geography textbooks

This study reveals a significant concentration of HOS content within the category of "Significant Events and Expeditions," while the categories of "Geographers and Explorers" and "Evolution of Geographic Theories and Ideas" are notably underrepresented. This imbalance not only reinforces the stereotype of geography as a "dehumanized" discipline (Chacón-Díaz, 2022; Soltani, 2024) but also overlooks the history of geographic thought, which constitutes the essence of HOS (Ye and Cai, 2009). As Keighren et al. (2017) assert, HOS serves as a crucial tool for identity formation and professionalization, enabling students to situate themselves within the discipline and cultivate a sense of belonging.

To this end, we recommend a shift in the way HOS is integrated into geography textbooks that goes beyond a mere chronicle of events toward narratives that are intellectually richer and more humanistically focused. Specifically, three areas warrant attention. First, the presentation of the evolution of geographic theories and ideas should be enhanced, detailing shifts in core concepts such as "human–environment relationships" and "regional theories." Second, there should be greater inclusion of case studies on scientists with a particular emphasis on the contributions of female geographers. Highlighting their scientific ethos and personal attributes can effectively demonstrate the universality and diversity of scientific endeavors. Third, HOS content should be linked with contemporary scientific advancements to illustrate the dynamic and ongoing evolution of geography.

5.3 Refining the presentation of the history of science in geography textbooks

This study shows that the representation of the HOS in geography textbooks is predominantly static and characterized by supplementary texts and images designed for superficial engagement. This conclusion-oriented approach reduces HOS to a list of facts for memorization instead of using it as a pedagogical tool for deeper understanding and critical thinking (Henke and Höttecke, 2015). This methodology not only is misaligned with the principles of inquiry-based HOS education (Khishfe and Abd-El-Khalick, 2002) but also risks increasing students' cognitive load without achieving the profound goal of fostering critical thinking (Ye, 2019).

To address this challenge, a pedagogical shift is needed: textbooks must evolve from being mere containers of knowledge to serving as scaffolds for inquiry.

Within a textbook's "surface system," which comprises texts, images, and activities, the focus should move beyond static content. We advocate for the design of more specific reflective activities that stimulate cognitive conflict and deep thought. Examples include case-based debates (e.g., a structured debate on "Wegener's Dilemma," where students assume the roles of supporters and opponents), thought experiments, and historical roleplaying scenarios.

Within the "deep system," the underlying framework of geographic knowledge, thinking modes, and values (Xia,

2003), HOS should be utilized as a vehicle for instilling core geographic competencies. This approach guides students to appreciate the dynamic, tentative, and socially constructed nature of science within historical contexts, thereby facilitating their transition from passive knowledge receivers to active critical thinkers.

5.4 Expanding the educational value of the history of science in geography textbooks

This study reveals that the history of science presented in geography textbooks often suffers from a monolithic value orientation, a limitation that requires renewed appreciation for the interdisciplinary strengths of geography. Ideally, geography should function as a bridging discipline that integrates scientific rationality with humanistic literacy. In practice, however, this interdisciplinary advantage is often significantly diminished. This attenuation can be attributed to several factors: prevalent public misconceptions about the discipline (Abler, 1987; Sun et al., 2011), the traditional emphasis on regional geography in Chinese education, a legacy of the country's significant regional diversity (He and Wang, 2013), which often skews curricula toward humanistic and social content, and a significant discrepancy between "academic geography" and "school geography," which creates a gap between scholarly knowledge and classroom instruction that impedes the in-depth exploration of HOS (He et al., 2022).

To address these shortcomings, future geography textbooks should fully leverage geography's interdisciplinary character when incorporating HOS. On the one hand, this involves enriching the fundamental understanding of HOS. Instead of presenting a simplified narrative, textbooks should use multifaceted narrative strategies. This approach would allow for a deeper exploration of the details within HOS and a comprehensive presentation of the underlying philosophical positions and diverse value orientations, thereby ensuring both scientific accuracy and intellectual depth. On the other hand, HOS should be explicitly linked to major contemporary issues. For instance, by highlighting the educational value of HOS in addressing complex challenges such as climate change and international disputes, the curriculum can move beyond merely enhancing scientific literacy to also cultivate students' capacity to navigate uncertainty and complex problems, thereby fully realizing geography's dual mission: to foster both scientific understanding and informed modern citizenship.

6 Limitations

This study contributes to the field by advancing an analytical framework for HOS in geography textbooks, thereby addressing a notable research gap and offering a methodological reference for similar inquiries. Nonetheless, Nonetheless, this framework provides primarily a structural lens and does not enable an in-depth examination of HOS from philosophical or epistemological perspectives. However, the findings should be interpreted in light of several limitations. First, our analysis was restricted to a specific textbook volume, the seventh-grade, first-semester edition for junior high schools in China, which prevented a comprehensive examination of textbooks across all grade levels. Second, the limited temporal scope of the selected textbooks precluded a longitudinal investigation of how HOS representations may have evolved over time.

These limitations, however, highlight clear directions for future research. Subsequent studies could refine and extend the analytical framework to incorporate philosophical and epistemological dimensions, thereby enabling more nuanced insights. They could also systematically broaden the sample to include textbooks from various grade levels and historical periods. For a more holistic perspective, empirical evaluations integrating analyses of teaching practices could be conducted. Such an approach would deepen the understanding of the pedagogical role of HOS in geography education and allow for the generation of more representative and generalizable conclusions.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft. YL: Validation, Visualization, Writing – review & editing. KW: Writing – review & editing. MZ: Writing – review & editing. SC: Data curation, Project administration, Supervision, Validation, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Publisher's note

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