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Pathway Design, Implementation, and Effectiveness Evaluation of the Grand Canal Cultural Heritage Resources in Geographic Science Education

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Abstract: The organic integration of cultural heritage geographical resources into geographical science education can enhance students' comprehensive understanding of history, geography, and social development, thereby promoting interdisciplinary thinking and scientific literacy. Taking China's ancient Grand Canal as a typical case, this study systematically explores the pathway design, implementation process, and effectiveness evaluation of transforming the geographical resources of the Grand Canal's cultural heritage into carriers for geography science education. Through a literature review, case analysis, and teacher practice observation, the study reveals: 1) effective strategies for embedding the historical and geographical background of the canal, its spatial network, and regional economic elements into the curriculum; 2) the role of immersive, contextualized, and inquiry-based instructional design in improving students' geographical cognition, inquiry abilities, and sense of social responsibility; and 3) a framework for effectiveness evaluation based on multiple assessment dimensions and an operational indicator system. The research results hold theoretical and practical significance for secondary geography science education curriculum reform, teacher professional development and cultural heritage conservation education. They provide applicable curriculum packages and evaluation tools, facilitating promotion and application in different regions. The limitations of this research lie in the regional specificity of the case and data availability; future studies should expand to cross-regional comparative studies and long-term follow-up assessments.

Keywords: Cultural Heritage; Human Geography; Science Education; Beijing-Hangzhou Grand Canal

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1.Introduction

As one of the most important hydraulic engineering projects in Chinese history, the Grand Canal not only played a crucial economic, cultural, and transportation role in ancient times, but today it continues to hold great value in cultural heritage, ecological protection, and modern development. In recent years, the nation has been increasing its efforts to promote scientific literacy. The Outline of the National Scientific Literacy Action Plan (2021-2035) emphasizes the need to enhance public scientific understanding through various science popularization activities, especially in areas such as environmental protection and the construction of ecological civilization, aiming to improve scientific literacy and environmental awareness across society. The social significance and necessity of conducting geographical science popularization: Geography is both

an ancient and young science. It is the study of the structure, features, and evolutionary patterns of the environment in which humans live, as well as the relationship between humans and the geographical environment [1]. However, the scope of human geography is vast and its content is diverse. To make science popularization education simpler, easier to understand, more interesting and representative, this article selects the ancient Grand Canal of China as an example to explore effective teaching methods for popular science in human geography.

2.Analysis of the Value of Integrating the Geographical Resources of the Grand Canal Cultural Heritage into Human Geography Teaching

The study of human geography resources can feel unfamiliar to students, and with limited instructional time, it is often challenging for learners to grasp the content quickly, which can diminish the effectiveness of science popularization. By contrast, the Grand Canal, a World Heritage site, embodies a wealth of historical, cultural, and geographic information and possesses distinctive features such as typicity, accessibility, and relevance to contemporary life. These qualities confer unique advantages for science popularization and education. Since the 1990s, global research on World Heritage preservation and the worldwide strategy for heritage management have advanced, giving rise to important international trends. In particular, cultural landscapes have increasingly become focal points for conservation efforts among scholars and policymakers [2]. Integrating the Grand Canal into human geography popularization enables students to deepen their understanding of the spatial characteristics of regional geography and the dynamic interactions between geography and human activity. Through case-based learning, students enhance their comprehension and application of geographic knowledge, thereby improving the effectiveness of science popularization. By examining concrete examples along the canal, learners gain insight into how historical processes shape present-day landscapes and how economic, social, and ecological dimensions interact. Incorporating multimodal resources—such as maps, imagery, field observations, and data visualization—can boost engagement and learning transfer. In sum, embedding the Grand Canal into human geography popularization not only enriches students' understanding of regional geography and human-environment relations but also provides a practical pathway to improve public scientific literacy, cultural heritage conservation, and sustainable development.

2.1 Enrich Geographic Awareness and Deepen Historical Understanding

Human geography education can cultivate students' philosophical literacy by integrating "time, space, and people," as well as foster in them a correct view of population, a dialectical view of resources, a harmonious view of the relationship between humans and nature, and a scientific outlook on development. It can also help them develop good behavioral habits [3]. The diversity of the Grand Canal's geographical resources provides abundant materials and case studies for popular science education in human geography [4], enhancing the classroom's interest and accessibility. This better motivates classroom engagement and promotes exchange and discussion between teachers and students. By integrating the resources of the Grand Canal into popular science education, students can gain a more intuitive understanding of the relationship between geographical spatial distribution and human activities. For example, by studying the route of the Grand Canal and the temporal and spatial evolution of traditional settlements along its path, students learn how the natural environment influences social development and how ancient people used their wisdom to overcome natural obstacles to accomplish this great project. This, in turn, enhances their understanding of historical culture and strengthens their sense of national identity.

2.2 Enhance inquiry skills and foster integrative thinking

As a historic project, the Grand Canal involves knowledge from multiple academic disciplines. During the learning process, students need to analyze or reflect on issues from various perspectives, activating their existing knowledge to connect abstract geographical concepts with the real world and developing interdisciplinary comprehensive thinking skills. By incorporating cooperative inquiry and group discussion sessions into teaching, students not only learn how to think independently but also draw from others' viewpoints through collaboration, fostering a more well-rounded way of thinking.

2.3 Enhance awareness of protection and strengthen sense of responsibility

Amid rapid urbanization, there is a clear trend of cultural evidence disappearing and unique cultural characteristics being lost along the Grand Canal; in some areas, even cultural discontinuity has emerged, making the scientific protection and active transmission of Grand Canal culture an important task [5]. By integrating ecological issues related to the Grand Canal

into teaching—for example, the Sanwan issue in Yangzhou—students can understand how human activity impacts cultural heritage and the ecological environment. This also allows them to deeply appreciate the urgency and responsibility of protecting cultural heritage, helping to cultivate responsible citizens for the future.

3.Example of popular science teaching design: "The Ancient Grand Canal of China"

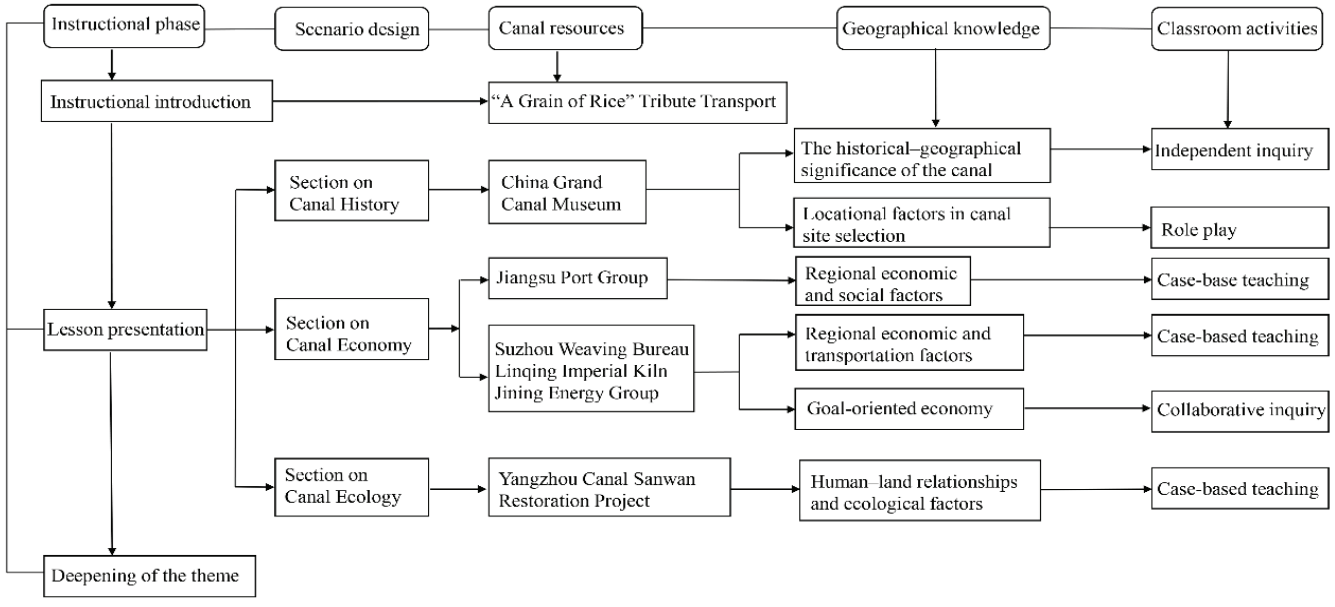
3.1 Teaching objectives

With reference to materials on the development of the Grand Canal, understand the historical background, economic impact, and cultural value of the Grand Canal, and comprehend its unique position in China's geography and history; analyze the influence of economic, social, transportation, and natural factors in the regions along the Grand Canal, and summarize the various types of targeted economies that emerged from the Canal; examine the changes in the ecological environment since the development of the Grand Canal, analyze the mutual influences between human activities and ecological factors, enhance ecological protection awareness, and foster a perspective of sustainable development.

3.2 Course design strategy

This popular science teaching program uses the cultural heritage of the Grand Canal as a vehicle to conduct story-based situational teaching, helping students understand the value of the Grand Canal from multiple dimensions such as geography, history, culture, economy, and environment. The program adopts an immersive "story-based situational teaching" approach to create an online study environment, enhancing the fun and appeal of geography lessons [6]. The teaching is divided into modules on the history of the canal, the canal's economy, and the canal's ecology, progressing step by step and forming a coherent whole. At the same time, the curriculum incorporates knowledge about the Grand Canal's historical background, geographical resources, and ecological protection, blending activities such as virtual tours, case studies, cooperative inquiry, and role-playing. Through interactive learning, students deepen their understanding of the Grand Canal and its cultural heritage (see Figure 1).

Figure 1. Course design strategy



3.3 Course teaching process

3.3.1 Introduction to new lesson

Introduce the curation theme of the Sui and Tang Grand Canal Museum—"A Grain of Rice" and its transportation by canal. In the early Tang Dynasty, during the Wude and Zhenguan periods, "canal affairs were simple," and most tribute grain came from the traditional tax bases, specifically the middle and lower reaches of the Yellow River. During the reigns of Emperor Gaozong and Empress Wu, as central expenditures increased dramatically, canal transportation further developed [7]. From the perspective of seeing the big picture through small details, understand how the Grand Canal played the role of a "ship" in the grain transport system. Allow students to immerse themselves in and experience the bustling activity along the canal's banks

and the technology of a "delivery across a thousand miles."

3.3.2 Teaching the New Lesson Section One

The History of the Canal teaching method was discussed in this section. Embark on an immersive cloud tour of the Sui and Tang Grand Canal Museum to learn about the historical and geographical significance of the ancient Grand Canal's construction, as well as the factors influencing its site selection (Table 1).

Table 1. Teaching process of the history of Grand Canal

Knowledge	Teacher activity	Student activity
The historical and geographical significance of the canal	Case study — Understanding the deeper meaning of the canal as a north–south bridge [Demonstration] Overlay of the Chinese terrain map with the canal route Material I: On the map of China, the Great Wall and the canal align to form a giant character " 人 " (person). The Great Wall extends from the northwest to the southeast—a defensive boundary; the canal runs from Beijing to Hangzhou—a channel for economic and cultural exchange. This single " 人 " character embodies five thousand years of the Chinese nation's survival wisdom. Material II: In 360 BCE, the Warring States period saw the construction of a canal between the Yellow River and the Huai River—the Hong Gou. The Hong Gou connects the Yellow River in the north to the Huai River in the south, leveraging the Yellow River's water flow to sustain bustling navigation and substantial grain transport into the Guanzhong region. Today, its name is memorialized in the Chinese chessboard as the Chu–Han boundary (楚河汉界). [Problem-driven prompt] Observe the map and describe the spatial configuration formed by the Great Wall and the canal as a " 人 " shape. Why is the canal considered the single vertical stroke (the " 捺 ") of the character? What is the significance of this stroke for the development of the Chinese nation?	Observe the map, read the materials, and think about the canal's unique position within the fabric of Chinese civilization; actively participate in the discussion.
Driving factors of site selection	Cooperative Inquiry — Investigating the Natural and Human Factors in Canal Site Selection [Display] Map of the Grand Canal (Beijing–Hangzhou) route with sectional profiles [Task-driven] Divide students into a "Natural Geography Group" and a "Historical–Cultural Group" Natural Geography Group: Analyze how the canal route utilizes natural waterways, avoids mountainous terrain, and connects the five major water systems Historical–Cultural Group: Analyze how the canal connects important capitals (Beijing, Luoyang, Hangzhou) and key economic centers	Group inquiry: analyze the advantages of canal siting from two perspectives—natural geography and the humanities/historical context. Group representatives present their research findings. The activities aim to cultivate students' holistic thinking and regional awareness, train them to analyze the locational factors of major engineering projects from multiple angles, and deepen their understanding of human–environment interactions.

Chapter two is Canal Economy. This study systematically explores differences in site selection among enterprises along the Grand Canal by visiting representative firms, and analyzes the economic types and development models embodied by these firms. Through examination of each firm's growth context and regional conditions, the analysis reveals the role of locational factors in shaping corporate competitiveness and how geographical and economic elements jointly mold regional industrial patterns. The aim is to provide structured evidence and theoretical interpretation to support subsequent comparative research and to inform cross-regional economic coordination and urban planning decisions (Table 2).

Table 2 Teaching process of Canal Economy

Knowledge Point	Teacher Activities	Student Activities	Design Rationale
Regional economy and social factors	Case study: investigate the decisive influence of policy on canal economic activity. Display materials related to Ming–Qing canal transport and Yangzhou salt trade. Material 3: Transport of granaries was the economic lifeline of the Ming–Qing state; the court appointed a Grand Supervisor to manage it, establishing a rigorous system for requisition, transport, and storage, with escort by transport troops. Material 4: Yangzhou salt merchants monopolized the transport and sale rights of the Two Huai salt trade. Under the Ming Salt Administration's "Salt Subsidy" policy, merchants were invited by the government to transport grain, exchange for salt drafts, and use drafts to purchase and sell salt at designated locations. Their rise benefited entirely from the state's "Salt Draft" system, leveraging the canal to move sea salt to designated areas and accumulating substantial wealth.	In groups, undertake a task-based inquiry to understand the process of the salt-draft system and evaluate policy impacts on regional economy.	Through historical policy cases, cultivate students' ability to analyze how social factors influence regional economic development and understand the role of policy in economic growth.
Regional economy and transportation factors	Explore the canal as a transportation artery and its role in regional economic growth. Display Ming–Qing era waterway maps for Linqing and Yangzhou. Material 5: Linqing, located at the junction of Hui and Wei rivers on the Grand Canal, was a key northern grain transfer and commercial hub.	Conduct case-based inquiry, analyze the canal's role in commodity circulation and regional development, and discuss guiding questions.	Develop students' ability to analyze the impact of transportation on regional economy and understand the importance of transport corridors in economic planning.
Directional industry	Collaborative inquiry: identify different types of directional industries.	Read and analyze materials; work in groups to investigate the industry orientation, summarize leading factors, location selection principles, and spatial layouts; group representatives report findings.	Foster teamwork and a systematic understanding of how the canal promotes various industries, and clarify the characteristics and location logic of directional economies.

Chapter three is Canal Ecology. This chapter examines the Yangzhou "Three Bays" restoration project to explore how human–environment and ecological relationships interact, and to understand the ecological development and changes along the Grand Canal. The study focuses on hydrological regulation, biodiversity conservation, and wetland restoration, analyzing how restoration measures reconcile the functional demands of the historic water network with contemporary ecological needs. By employing a combination of quantitative indicators and qualitative observations, it assesses the integrated effects on flood safety, water quality, ecological tourism, and community engagement, and aims to provide transferable theory and practical guidance for ecological governance in the canal watershed (Table 3).

Table 3 Teaching process of Canal Ecology

Knowledge Point	Educational Activity	Student Activity
Human–environment relations and ecological factors	Case study: Analyzing the transformation of Yangzhou's Sanwan from an "industrial scar" to an "urban green lung" as a case of evolving human–environment relations in environmental governance [12].	In groups, design and analyze an "Ecological Restoration Flowchart," tracing the transformation from environmental degradation to restoration; use the case to illustrate how human–environment relations shift from conflict to coordination.

Knowledge Point	Educational Activity	Student Activity
[Display] Sanwan before-and-after visuals	Present historical vs. current landscape comparison images of Sanwan, highlighting the shift from heavily polluted industrial areas to ecologically rich wetlands and parks.	Use the visuals to identify key indicators of ecological improvement and generate questions for further inquiry.
[Problem-driven] Implications of ecological transformation	Pose and discuss the implications of Sanwan's environmental transition for ecology, society, and governance.	In groups, synthesize the essential elements of ecological restoration and compose concise, evidence-based conclusions.

3.3.3 The Historical Wisdom and Modern Mission of the Grand Canal

Classroom Summary: The Grand Canal Cultural Belt embodies not only historical, cultural, and socio-economic value but also aesthetic and educational significance. From the initial excavation in the Sui dynasty to later restoration and expansion, the construction and maintenance of the canal have mobilized countless artisans, scholars, merchants, and diverse talents in a collective effort. Innovation and wisdom are the enduring keys that keep the canal luminous across millennia; it symbolizes not only the ingenuity and courage of ancient Chinese people but also their spirit of striving for a better life under challenging conditions. Youth in the new era should also contribute to the development and transmission of the Grand Canal.

Rationale: As a UNESCO World Heritage Site, the Grand Canal's geographic resources integrated into human geography education can help students deeply appreciate the far-reaching significance of cultural heritage conservation.

4.Conclusions

Integrating the Grand Canal into science education does more than enrich a single subject; it broadens geographic pedagogy, deepens interdisciplinary understanding, and strengthens cultural self-confidence across generations. By making the canal a living presence in the classroom, students move beyond rote memorization of locations to an exploration of the dynamic interactions between physical geography and human decision-making. They observe how riverine pathways shape settlement patterns, trade networks, and urban development, and how these patterns reflect broader social, political, and economic forces across different historical periods. This experiential approach reveals the canal not merely as a historical artifact but as a living system whose presence continues to influence contemporary urban life, regional planning, and environmental policy. The process invites learners to consider multiple scales—from local watershed management to national economic strategy—and to see how small-scale decisions can have long-term, wide-reaching consequences.

Moreover, studying the Grand Canal underscores the richness of cultural exchange and economic resilience along a major waterway. Students encounter narratives of artisans, merchants, engineers, and travelers whose interactions facilitated shared technologies, languages, and cultural practices. These stories illuminate how culture is created, transmitted, and reinvented through infrastructure projects, daily labor, and collective memory. As economies along the canal expand and diversify, learners gain a nuanced understanding of resilience: how communities adapt to changing trade routes, how governance mechanisms balance competing interests, and how sustainable development requires careful resource stewardship, inclusive policy-making, and collaborative leadership. In this context, ecological considerations become inseparable from economic and cultural objectives, highlighting the imperative to harmonize development with conservation, and to recognize the value of traditional ecological knowledge in informing contemporary stewardship.

Ultimately, Grand Canal geographic literacy serves as a powerful instrument for nurturing informed citizenship. It prompts reflection on ethical dimensions of progress—how to pursue development without erasing local identities or degrading ecological integrity, how to honor indigenous knowledge and community voices, and how to safeguard cultural heritage for future generations. By foregrounding the convergence of geography and history, educators can cultivate critical thinking about change and continuity, enabling students to analyze how technological innovations, climate variability, and globalization intersect with enduring cultural identities. The curriculum thus encourages a balanced perspective that honors legacy while imagining sustainable futures, guiding students to envision concrete actions they can take as responsible citizens. Through inquiry-based learning, data-driven reasoning, and collaborative problem-solving, learners develop transferable

competencies—analytical reasoning, evidentiary argumentation, cross-cultural communication, and ethical deliberation—that empower them to contribute meaningfully to heritage preservation, environmental stewardship, and sustainable development. In this sense, integrating the Grand Canal into science education is not merely about transmitting facts; it is about fostering a sense of belonging to a shared human story and cultivating the courage to act as stewards of that story. By understanding the intersection of geography and history, students glimpse the power of civilization and recognize the potential within themselves to shape a more informed, compassionate, and resilient society. In taking concrete actions to safeguard cultural heritage and ecological integrity, they assume citizen-level duties and commitments—today, tomorrow, and for generations to come.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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