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Exploration of the Path of Natural Science Popularization Resources from University Museums to Rural Areas: Taking the Natural Decoder Project of a College in Qingdao as an Example

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Abstract: *Currently, there is a shortage of physical specimens and complete course supplies in rural natural science popularization. The abundant rare specimens and exhibition resources in university museums are multi-faceted and difficult to radiate to the countryside. The imbalance between urban and rural science popularization supply and demand restricts the equal development of services. This article takes the "Natural Decoder" project as a case study, combined with field research and activity data, to analyze the practical obstacles to the popularization of science resources in university museums going to the countryside and to sort out solutions for the project's implementation. Research shows that the core dilemma of resource sinking lies in spatial barriers between urban and rural areas, insufficient adaptation of library content to rural teaching, and weak long-term effectiveness of single science popularization activities. Practice has proven that promoting the pedagogical transformation of library resources and building a long-term sustainable service model is the core path to breaking the supply-demand gap, which can provide practical reference for university museums to carry out rural science popularization.*

Keywords: *University museum; Rural popular science education; Natural education; Resource sinking; Mobile Museum*

1. Introduction

1.1 Research background

Scientific literacy forms the foundation of both national quality and a country's innovation capacity. The "National Scientific Literacy Action Plan Outline (2021－2035)" proposes that by 2035, the proportion of citizens with scientific literacy should exceed 15% and 25%, respectively, and calls for significant improvement in the uneven development of scientific literacy across regions and populations[1-2]. The plan specifically identifies youth and farmers as key groups, emphasizes building mechanisms to link science education resources inside and outside schools, promotes cooperation between museums and schools, and encourages primary and secondary schools to carry out practical learning activities using science centers and museums. Since the implementation of the "Double Reduction" policy, rural schools’ demand for quality education has risen, making the need for high-quality science popularization resources even more urgent. Research has pointed out that rural science education faces shortcomings such as lack of experimental equipment, insufficient science courses, and weak full-time teaching staff, with some schools replacing hands-on experiments with lectures. The pilot project for precise services with mobile science popularization facilities addresses this issue institutionally, with the 2026 science popularization caravans focusing on 90 county-level administrative regions in the 13 provinces and Xinjiang Production and Construction Corps that have the scarcest science and education resources, with more than 60% of the sites located in towns. University museums are an important part of science popularization infrastructure, with rich collections, research accumulation, and talent reserves, but their social education function has long been aimed at urban audiences and campus students, and a systematic approach to serving rural areas has yet to be established. On one hand, rural science popularization resources are severely lacking; on the other hand, resources in university museums are underutilized, highlighting a growing structural contradiction.

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In recent years, some universities have started exploring feasible ways to extend museum resources to rural areas. The Museum of Huazhong Agricultural University, leveraging nearly 300,000 artifacts, has used the "mobile museum" as a platform to provide regular science services in rural primary and secondary schools in Hubei, integrating local ecological science education with ideological and moral education[4]. The "Little Water Drop Public Classroom" team at Northeast Forestry University has converted laboratory and museum resources into mobile courses, starting a decade ago in Tailai County, Heilongjiang, and gradually expanding to Yunnan, Fujian, and other areas, serving over ten thousand primary and secondary students in total[5]. These practices show that university museum resources have the potential to reach rural areas, but their institutionalized and sustainable operational mechanisms still require in-depth study.

1.2 Research value

This article focuses on the practical bottlenecks and implementation paths of the natural science popularization resources of university museums sinking into rural areas. The reason why the research problem is worth exploring is twofold: on the one hand, existing literature pays more attention to the design of educational activities in venues, and there is insufficient exploration of the mechanism for the effective connection between university museum resources' going global' and rural schools; on the other hand, rural science popularization education has long relied on government projects and social welfare forces, and the existing resources of university museums have not been systematically utilized. This article takes the "Nature Decoder" project of a certain college in Qingdao as a case study, systematically sorting out the key links and feasible paths of resource sinking, aiming to provide reference for similar institutions to participate in rural science popularization education.

1.3 Research ideas and methods

This article follows the research mainline of "problem diagnosis path construction practice verification effectiveness extraction," adopts the case study method, focuses on the overall operation logic and key measures of the "Nature Decoder" project, and obtains first-hand practical information through field research and visits to rural schools, university museums, and participating teachers and students covered by the project; assisted by semi-structured interviews with project leaders, rural teachers, and students to understand their perceptions and evaluations of the effectiveness of resource allocation; on this basis, sort out the implementation data of the project in terms of the number of schools covered, service personnel, curriculum development volume, etc., and analyze the project's effectiveness and promotable value.

2. The Practical Path of the Natural Decoder Project

2.1 Multi-subject collaborative linkage—establishing a collaborative mechanism of "university-led + multi-party co-construction"

Balancing and effectively distributing science outreach resources is one of the key ways to bridge the gap in scientific literacy between urban and rural areas and promote educational equity. However, the smooth flow of resources from the supply side to the demand side is not just a simple physical movement; it's a complex system that involves collaboration among multiple parties and coordination across many steps. Its effectiveness depends on establishing a clear, orderly, collaborative mechanism as the foundational institutional guarantee for the project's operation.

With this in mind, the project clearly defined the roles and collaboration responsibilities of all participants from the very start. University museums, as the core suppliers of science resources, handle professional tasks such as providing specimens and digital resources, developing course content systems, and guiding teaching and research methods. Their role ensures the scientific and systematic quality of the science outreach. Rural schools, as the end-point for resource implementation, are not only responsible for providing the teaching space and maintaining daily classroom order but also for giving dynamic feedback on students' foundational knowledge and changing interests, providing empirical support for future course iterations. University student volunteers act as key connectors between the resources and the audience. Their responsibilities include teaching on-site, guiding interaction sessions, and handling unexpected situations, making them the practical carriers of turning science outreach concepts into tangible experiences. Digital platforms aim to expand the time and space boundaries of science outreach, taking on tasks such as recording and distributing online courses,

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collecting and organizing multidimensional learning data, and tracking and analyzing communication effectiveness, providing technical and decision-making support for the project.

Based on this clear division of roles, the project focuses on building a multi-directional network led by the government, supported by universities, implemented by schools, and engaged by society. In terms of funding, it actively seeks multiple channels such as corporate charitable donations and foundation grants to ease financial constraints. In terms of talent development, the project recruits university students who are both willing to serve and professionally capable as volunteers, and also identifies and trains local rural talent with teaching potential to improve the localization and sustainability of the service team. Through institutionalized role division and networked collaboration, all parties gradually form a community of shared responsibility with aligned goals, complementary strengths, and information interchange, providing a sustainable internal driving force for distributing science outreach resources**.**

2.2 Curriculum Innovation and Scene Extension—Creating an "Experiential+Immersive" Science Popularization Activity System

Innovating course formats is a key breakthrough to bridging the 'practical gap' between the supply of popular science and rural children's cognitive reception. Traditional popular science activities often rely on one-way knowledge transmission. Although they provide dense information, they overlook the cognitive development characteristics of rural children, who primarily learn through concrete experiences, making it difficult for popular science content to be internalized into scientific thinking and inquiry skills. To address this issue, this project has systematically designed a course format that integrates 'hands-on practice, situational experience, and project-based inquiry,' aiming to build a practical teaching bridge between 'learning by doing' and 'understanding through thinking.'

On the curriculum development side, the project team leverages the disciplinary advantages and research accumulation of university museums and has completed the systematic construction of 126 natural education-themed courses. The course content spans a diverse range from microscopic specimen creation to macro ecological observation, and the materials have been developed with a graded approach, forming a set of 16 textbooks across 4 series. This system aligns content difficulty, activity complexity, and cognitive challenge with the psychological development levels of rural primary school students from lower, middle, and upper grades, ensuring that popular science activities are both educationally deep and fun to participate in. Specific course modules cover basic operations like making insect and plant specimens, field observation of small ecosystems around farmland, and miniature scientific inquiry projects such as water quality testing and pollination behavior recording, allowing students to develop a preliminary understanding of natural science and methodological awareness in tangible, hands-on contexts.

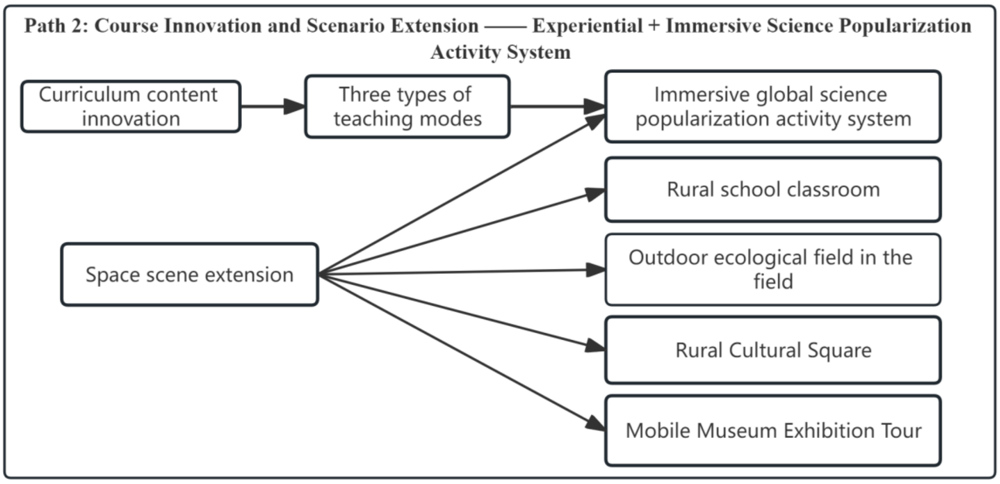

Figure 1: Course Innovation and Scenario Extension—Experiential + Immersive Science Popularization Activity System

In terms of extending the learning environment, the project deliberately breaks through the physical boundaries of museums, expanding the main venues for popular science education from specialized display spaces to everyday classrooms in rural schools, production landscapes in fields, and public

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cultural squares in rural communities. To address the challenge that rare specimens are difficult to bring to rural schools due to transportation and display constraints, the project has implemented a 'mobile museum' campus tour system, delivering over 4,000 mineral, fossil, and rare plant and animal specimens to rural schools in a modular exhibition format. This not only shortens the physical distance between rural children and high-end science resources but also reshapes the logic of popular science education through spatial transformation—allowing scientific knowledge to return to the natural and social contexts from which it arises, enhancing the authenticity and meaningfulness of learning[3][6]. As shown in Figure 1, through this dual innovation of course formats and learning spaces, the project has initially built a flexible, localized pathway for rural popular science implementation, offering a reference model for similar initiatives.

2.3 Talent cultivation and local empowerment—building a teacher support system of "external transmission + local cultivation"

Talent guarantee is the core element for the landing of science popularization resources in rural areas. This project aims to build a stable scale of college student science popularization volunteer team, including more than 100 core backbone volunteers and over a thousand registered volunteers. It constructs an integrated management system for recruitment, training, service, and motivation, and relies on museum professional teachers to carry out systematic pre-job training around specimen cognition, explanation, and expression, and course development.

2.4 Long-term guarantee and mechanism optimization—improving the support system of "funding+system+evaluation"

Long-term operation relies on diversified funds and standardized management systems. The project coordinates three types of funds: special funds from universities, local finance, and social donations, to support curriculum research and development, offline activities, and rural teacher training; introduce special management regulations, unify the operational standards for the entire process of science popularization activities, and provide supporting and improved safety management rules. As shown in Figure 2, quality control introduces the CIPP evaluation model, which conducts evaluations around four dimensions: curriculum, resources, teaching, and effectiveness. It continuously iterates content based on feedback from students, schools, and third parties, forming a complete optimization loop.

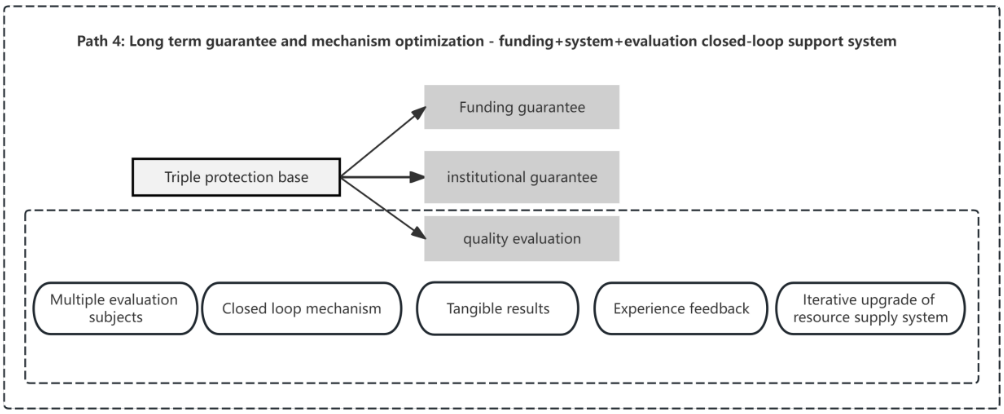

Figure 2: Long term guarantee and mechanism optimization—funding + system + evaluation closed-loop support system

3. The Implementation Effectiveness of the Natural Decoder Project

3.1 Rural science popularization coverage and improvement of students' literacy

The radiation scope of the project continues to expand. Now, 46 rural schools have been set up, and the service area extends from Qingdao West Coast New Area to Xinjiang, Xizang, and other places, benefiting more than 800,000 students online and offline; By 2026, a total of 252 science popularization lectures will be conducted, providing offline services to over 20,000 people. The study

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used a pre-test, intervention, and post-test model to assess students' literacy. Before the activity, less than 15% of students were able to identify 5 native wildlife species, but after the course ended, this proportion increased to over 65%; More than 70% of students have significantly increased their interest in scientific exploration, and some have spontaneously formed campus nature observation clubs. The overall evaluation of the school is good, with over 80% of the interviewed schools recognizing projects to fill the gap in science popularization resources on campus. 42% of partner schools have included science popularization courses in after-school services, promoting the transformation of science popularization services from short-term enrollment to regular implementation.

3.2 Resource activation and social recognition

The project effectively revitalized the collection resources, with over 4000 specimens transported to rural areas through mobile exhibition halls and digital platforms, and over 120 precious specimens completed 3D modeling for online use by rural schools. The project has recruited over a thousand volunteers and collected more than 2300 questionnaires, forming a service optimization loop. The project has won multiple provincial and municipal science popularization honors, and the cooperative units continue to expand: more than 30 science popularization activities have been jointly carried out with local libraries[7], assisting local museums in carrying out theme promotion, and jointly building multiple natural practice bases for primary and secondary schools. The collection value and social science popularization brand effect have been synchronously improved.

3.3 Local Capacity Building and Ecological Sprout

The project focuses on cultivating endogenous abilities in local science popularization in rural areas. Among the 46 cooperative rural schools, more than 30 teachers have mastered the skills of science popularization course design, specimen explanation, and natural observation activity organization through special training. Some schools rely on supporting specimen corners to establish a normalized on-campus science popularization operation mode. At the same time, the project has established a mature volunteer cultivation and incentive system, with more than a thousand registered college student volunteers and over a hundred core backbone members forming the main service force. Returned youth and rural talents actively participate in the service, laying a solid talent foundation for the long-term localization development of the project.

4. Experience insights

To promote the long-term sinking of library resources into rural areas, it is necessary to grasp the two core logics of precise adaptation and multi-party collaboration. On the one hand, we must adhere to a demand-oriented approach. The professional content of university collections cannot be directly adapted to rural classrooms. In the early stage of the project[8], field research will be conducted to develop local science popularization courses based on rural learning conditions and regional ecology. The proportion of local species content in the courses will exceed 50%, avoiding the problem of simple transplantation of urban science popularization content. On the other hand, it is necessary to establish a diversified collaborative system. The supply of science popularization, curriculum development, and venue landing cannot rely on a single entity. The project should build a chain of linkages between universities, volunteer teams, rural schools, and digital platforms to form a stable operating system.

At the same time, the project has formed four replicable promotion paths: firstly, standardizing the resource conversion process, relying on research, screening, and localization transformation to achieve resource adaptation; The second is a multi-party collaboration framework that clarifies the rights and responsibilities of universities, governments, schools, and society; The third is the local teacher training model, which relies on endogenous forces to ensure the long-term development of science popularization; The fourth is the digital science popularization system, which relies on 3D specimens and online courses to compress long-term service costs.

5. Conclusion

This article takes the "Nature Decoder" project of a certain college in Qingdao as a case study to analyze the practical difficulties and solutions of sending science popularization resources from university museums to rural areas. Research has found that the imbalance between urban and rural

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science popularization supply and demand can be alleviated through resource integration, multi-party collaboration, localized curriculum transformation, local teacher training, and long-term operational mechanisms. After nearly a decade of practice, this project has built a dual-track service model of "mobile museum + digitalization," which has been implemented in 46 rural schools and verified its practical value.

This study still has limitations, as the case sample is concentrated in different regions, and there are significant differences in rural development conditions. The universality of the relevant promotion paths needs further verification; at the same time, mechanisms such as project funding guarantees and the long-term growth of local teachers also require long-term tracking and observation. Subsequent research can broaden the sample of cases and compare the practices of different types of university museums; deepen research on the application of digital science popularization and explore low-cost and widely covered technical solutions; improve relevant policy design to provide institutional support for the normalization of rural science popularization in university museums.

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