



Geoheritage Education as a Gateway to Developing a Conservation Ethic in High School Students from China and the USA

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Abstract

A recent summary of geoheritage and protected area management as reported by Gordon (*International Journal of Geoheritage and Parks* 7:199–210, 2019) notes that a broader discipline has been emerging in geoheritage that recognizes the links to landscape and biodiversity conservation, economic development, climate change adaptation, sustainable management of land and water, historical and cultural heritage, and geotourism. Our focus in this study is to emphasize that geoheritage can serve as a gateway to developing a broader conservation ethic by developing educational programs that have a broader aim of interpretation, education, and enjoyment. Ultimately, these enjoyable educational experiences in areas of geoheritage value lead to a deeply felt conservation ethic. The US National Park Service recognizes the progression as “through interpretation, understanding; through understanding, appreciation; through appreciation, protection” as discussed by Tilden (1957). We have been working towards this goal through the expansion of a high school environmental education program in the USA, the National Conservation Foundation Envirothon, to China. The Envirothon is an environmental education program that culminates in the annual NCF-Envirothon Competition in which winning teams from participating states and Canadian provinces compete for recognition and scholarships by demonstrating their knowledge of environmental science and natural resource management. Much of the field education and field competitions are held in areas protected for their geoheritage and biodiversity values, and this use of geoheritage as a gateway to the broader educational goals is central to the program. We have been seeking to broaden the influence of the Envirothon program and underlying conservation goals in China. With educational curriculum reform since 2000 in China, students are encouraged to have more project-based learning opportunities and field-based experiences. The group at Beijing Normal University supports hundreds of high school partner programs. The Envirothon is a natural extension of this work and provides enhanced opportunities for international collaboration between the USA and China. Geoheritage value is a primary determinant of which areas are used for Envirothon field education and competitions; through this gateway, students from both countries will have educational, fun, and memorable experiences that will lead from understanding to appreciation to protection.

Keywords Conservation · Education · Geoheritage · Geoethics · International collaboration

Introduction

Exploring geoheritage is true time travel, and fortunately it is free and available to teachers and students around the world. Tales of the Earth, like the great super-eruption of the volcanic center beneath Yellowstone that blanketed America out to the Atlantic Ocean in glassy ash 1 million years ago; or the perfect fossil preservation in Liaoning Province in China, showing colored feathered dinosaurs and showing the evolutionary process from dinosaurs to birds 150 million years ago; or standing on the edge of Arizona’s Meteor Crater and realising that an extraterrestrial object crash-landed here 50,000 years ago all capture our imagination and cause

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us to wonder how things have changed since the time preserved in those rocks. The wonder extends to the future as well because the stories preserved in the stones all around us also suggest the future: the processes are ongoing.

As the understanding of geoheritage and its importance has developed, several important terms have come in to use (Crofts et al. 2020). Geodiversity is the variety of rocks, minerals, fossils, landforms, sediments, and soils, together with the natural processes that form and alter them. The elements of geodiversity provide the foundation for life on Earth, and they maintain natural capital and ecosystem services. Geoheritage comprises those elements and features of the Earth's geodiversity that are considered to have significant value for intrinsic, scientific, educational, cultural, spiritual, aesthetic, ecological, or ecosystem reasons and therefore deserve conservation. Geoheritage constitutes a legacy from the past to be maintained in the present and passed on for the benefit of future generations. Finally, geoconservation has been defined as "the conservation of geodiversity for its intrinsic, ecological and (geo)heritage values" (Sharples 2002; Crofts et al. 2020).

Running through each of these definitions is the concept that geodiversity supports biodiversity and cultural values as well, and that geoheritage and geoconservation are important for the abiotic elements they preserve and protect, as well as for other biotic values they support. Indeed, a recent summary of geoheritage and protected area management (Gordon 2019) notes that a broader discipline has been emerging that recognizes the links of geodiversity with landscape and biodiversity conservation, economic development, climate change adaptation, sustainable management of land and water, historical and cultural heritage, people's health and well-being, geotourism, and the delivery of socioeconomic benefits for local communities. At the root of these values is building a conservation ethic through education: helping to interpret geoheritage for our students in engaging ways that put them in the scene and trust that the wonder of the wet and rocky part of our planet (the geology) will be so captivating that they become apostles of a true environmental conservation ethic.

While geoheritage is certainly valuable in and of itself, its value in interpretation and education can be most engaging when the full ecosystem, biotic and abiotic, is described. Our focus in this study is to emphasize that geoheritage can serve as a gateway to developing a broader conservation ethic. The gateway leads from areas protected for geoheritage value to developing educational programs that have a broader aim of interpretation, education, and enjoyment of both the biotic and abiotic environment. Ultimately these enjoyable educational experiences in areas of geoheritage value lead to a deeply felt conservation ethic.

Through exchange of conservation information and plans between Beijing Normal University and the IUCN's

Geoheritage Specialist Group in 2019, we have been working towards this goal using the expansion of a high school environmental education program in the USA, the National Conservation Foundation Envirothon, to China. Envirothon activities typically take place in areas of geoheritage significance; include geology, soils, and hydrology as fundamental areas of enquiry; and extend to biological and cultural values displaying the range of conservation needs. China's education reform program since 2000 has included elements of both project-based learning and place-based learning. The Envirothon supports this goal directly; it is an environmental education program that culminates in the annual NCF-Envirothon Competition in which winning teams from participating states and Canadian provinces compete for recognition and scholarships by demonstrating their knowledge of environmental science and natural resource management. The program has a strong outdoor component, and is sponsored by the US Forest Service, the US Resource Conservation Service, and others. Much of the field education and field competitions are held in areas protected for their geoheritage and biodiversity values, and this use of geoheritage as a gateway to the broader educational goals is central to the program. A workshop was held at Beijing Normal University in January 2020 to expand the work to include science teachers and principals representing more than 50 high schools interested in participating in the program.

Putting Plan to Practice

Using geoheritage elements in projected areas in order to raise wider awareness and increasing involvement through education and interpretation are key parts of geoconservation. Telling the geological story of a protected area is the equivalent of telling people about a slice of Earth's history. It is typically fascinating and, prepared in an interesting way, can be compelling (Crofts et al. 2020). The International Union for the Conservation of Nature has established a Geoheritage Specialist Group to help introduce this appreciation through education programs in protected areas. One application has been our work to support expansion of the Envirothon to large parts of China.

What is the Envirothon?

The Envirothon is an outdoor natural resources competition for high school students grades 9–12. Students work in teams in the field to answer questions related to soil, water quality, forestry, aquatic biology, and wildlife, and the Envirothon includes an oral presentation on a scenario featuring the current environmental theme (e.g., groundwater, watersheds, biodiversity, renewable energy, invasive species, climate change). The role of geoheritage is

two-fold in this process. First, the field-based elements are typically held in protected areas of geoheritage significance. The educators use this valuable resource as an introductory element to the upcoming field work, explaining the geological history of the area and how it created the scenes around them. Second, the Envirothon includes specific geological elements in the series of focus areas, including geology and soils, hydrology, and water quality. This second element goes beyond the geological to display the importance of the abiotic portion of the ecosystem in supporting forestry, wildlife, aquatic biology, and environmental themes that typically involve the built environment.

Working collaboratively as a team, students learn through project-based learning, and the focus on field applications in areas of geoheritage significance is place-based learning (NCF Envirothon 2019). The Mission of the program is to develop knowledgeable, skilled, and dedicated adults who have an understanding of natural resources and are willing and prepared to work towards achieving and maintaining a balance between the quality of life and the environment, accomplished by developing in young people an understanding of the principles and practices of natural resource management and ecology and through practice dealing with complex resource management decisions (NCF Envirothon 2019).

The Envirothon culminates in an annual NCF-Envirothon Competition, in which winning teams from participating states and Canadian provinces compete for recognition and scholarships by demonstrating their knowledge of geological, biological, and environmental science and natural resource management. The program, which has a strong outdoor component, is sponsored by the US Forest Service, the US Resource Conservation Service, and other groups. Much of the field education and field competitions are held in areas protected for their geoheritage and biodiversity values, and this use of geoheritage as a gateway to a better understanding of environmental science is crucial to the program's success. The program is implemented locally by high school teachers; student teams work collaboratively during the school year to develop their knowledge of ecology and natural resource management and to practice their environmental problem-solving skills in preparation for Envirothon competitions (NCF Envirothon 2019).

Participating teams are trained and tested in five natural resource categories: Geology and Soils/Land Use, Aquatic Ecology, Wildlife, Forestry, and Current Environmental Issues. The program consists of in-class curriculum with hands-on outdoor field experiences, where students can learn natural resource management techniques from natural resource professionals. State and provincial competition winners advance on to the annual NCF-Envirothon international competition for prizes and scholarships.

The NCF-Envirothon works in partnership with local conservation districts; agricultural, forestry, and conservation organizations; and schools and cooperating natural resource agencies to organize and conduct competitions. The major elements include the following:

Aquatic Ecology: the study of marine and freshwater ecology to assess the quality of delicate aquatic ecosystems. Students learn how to identify aquatic organisms, manage watersheds, and mitigate the effects of non-point source pollution.

Forestry: the study of forest ecosystems through the help of professional foresters. The basics of species identification, forest structure and dynamics, as well as management techniques are learned by students.

Geology and Soils/Land Use: the study of geology as the support for biotic systems and learning about the amazing world below our feet from geologists, soil scientists, and conservationists. Geology as the fundamental source of the surrounding ecosystem, hydrology and water quality, and soil characteristics, structure, ecology, and conservation are explored.

Wildlife: the study of wildlife ecology, classification, adaptations, species identification, interactions with and impacts of human society, and the importance of wildlife and habitat conservation.

Current Environmental Issues is an integrated theme that changes each year and analyze environmental issues and take an in-depth look at some of the top environmental issues facing our world today. Students work as a team to explore the many facets of current environmental issues and the complexities of real-life decision-making.

Oral Presentations are the culmination of project-based learning. Using the knowledge learned from the core 5 topics, teams are given the opportunity to address a real-world environmental/natural resource issue and their ideas on addressing it. Working as a unit, the team must analyze a given scenario, develop a plan of action to address it, and then present their plan to a panel of judges for scoring (NCF Envirothon 2019).

The competition consists of a blend of in-class curriculum and hands-on field experiences that incorporate both indoor and outdoor learning opportunities for students. Teams work collaboratively to develop their knowledge of ecology and natural resource management and to practice their environmental problem-solving skills.

Each participating state or province will hold a competition, usually in the spring of each year. The winning team from each state/provincial competition is then eligible to attend the NCF-Envirothon Annual International Competition. Each team arrives at the NCF-Envirothon annual competition as a result of extensive training and superior

performance at state/provincial Envirothon competitions. More than 500 students, volunteers, and guests, representing up to 50 teams from three different countries, journey to the event to learn and compete in environmental ecology and natural resource management.

The week-long competition includes hands-on and written tests and oral presentations on the students' knowledge of aquatic ecology, forestry, wildlife, and soils/land use. Each team receives extensive on-site training to help familiarize themselves with the competition site, oftentimes a vastly different world from their home region. The competition culminates with an announcement of the winning teams and cash awards to be used as scholarships (NCF Envirothon 2019).

Why is the Envirothon a Good Fit for China's Curriculum Reform Goals?

Education in China is primarily managed by the state-run public education system, directed by the Ministry of Education. China's reform of its educational system has been ongoing since the end of the Cultural Revolution, and since 2000 reform has been conducted in the context of globalization (Yin et al. 2014). Curriculum reform is China's main human capital development strategy for coping with the challenges of the twenty-first century, and that the state plays an important role in the reform of curriculum-making mechanisms and in the social distribution of knowledge, skills, and dispositions through curriculum making (Wing-Wah Law 2014). China uses curriculum reform as a key strategy to counter manpower-related global challenges and to empower the country in the twenty-first century. To do so, China has re-oriented its curriculum making from a state-dominated model to one that is state-led, expert-assisted, and evidence-based. While preparing its students to compete globally, China also urges them to identify with and take pride in the nation's achievements and culture (Wing-Wah Law 2014).

With the multiple impacts of globalization, people involved in educational leadership in China are like their counterparts in other Asian countries confronted with the dilemma between traditional Confucian ethics and values and the new global values, such as decentralization, efficiency, and accountability (Yin et al. 2014). On the one hand, Chinese administrators believe the new Western educational ideas are effective for democratic education, collaborative learning, and close teacher-student relationships. On the other hand, they see Chinese traditional education's strengths as respect for teachers, emphasis on basic education, and high national and international examination scores (Yin et al. 2014).

The Chinese Ministry of Education has initiated the eighth round of national curriculum reform since June 2001. This nationwide reform involves the entire basic education

system which comprises 6-year primary education and 6-year secondary education segments. The secondary education is divided into a 3-year junior level and a 3-year senior level. Especially at the senior secondary level, there is replacement of the existing subject-based curriculum structure with an integrative, three-level structure consisting of learning fields, subjects, and modules; decentralization of the educational system and encouraging school-based curriculum development; granting students the authority to choose courses; and adopting an elective course and credit system.

In the context of this paper, there are two elements of the Envirothon that directly support the educational reforms. First, place-based learning is a primary element of the Envirothon, and this highlights the geoheritage and geodiversity of the field areas selected for activities. This fosters pride in China's highly diverse geoheritage areas and an understanding of how the underlying geology supports other ecosystem elements in the area. Second, the encouragement of the use of project-based learning is central to supporting skills such as communication, problem-solving, teamwork, and creative thinking and problem-solving. Influenced by global trends in the field of education, many concepts and practices originating from Western countries were advocated in this national curriculum reform. Examples are curriculum integration, decentralization, formative evaluation, and innovative teaching approaches (Yin et al. 2014). Envirothon is another technique derived from Western countries that fosters a conservation ethic, starting with geoconservation.

Beijing Normal University supports this educational reform through several programs that offer direct support to secondary education principals and science teachers. Ongoing curriculum reform in China demands that teachers and principals shift their norms of practice to facilitate student learning. Principals are expected to take a more hands-on approach and work more collaboratively with teachers towards curriculum change. Beijing Normal University provides the research and implementation support (Haiyan Qian and Allan Walker 2013).

Prior to the identification of the Envirothon as an excellent program that Beijing Normal University could use to support high school geography and geology educators, there had already been programs developed by Beijing Normal University for the secondary education programs. These include Geospatial Thinking and Its Application, a cooperative exchange program with James Madison University in VA, USA. The focus of this program is to use Geographic Information Systems to learn about new problems and geographies, while establishing connections across cultures. Another program is the Geography Olympiad, a competitive program initiated by International Geographical Union and currently popular in China. The Olympiad is a competition between individual students who are between

16 and 19 years old and selected through a national geography competition. The international Geography Olympiad consists of three parts: a written test, a multimedia test, and substantial fieldwork requiring observation, leading to cartographic representation and geographical analysis.

With the Envirothon, Beijing Normal University can build on these earlier geography and geospatial learning programs to include both place-based and project-based learning into China's curriculum. The program is broader in scope, is more project- and team-oriented, and begins with a strong grounding in geoheritage to build a conservation ethic that also includes appreciation of the connections between abiotic and biotic nature and the built environment.

Putting It All Together

The Envirothon's emphasis on both project-based learning and place-based learning makes it a perfect fit for enhancing natural science education in China. Geoheritage and geodiversity are central to the program, both in the field areas selected for work, and in specific work elements. By broadening the influence of the Envirothon program and its underlying conservation goals in China, this work provides a platform for project-based learning opportunities and field-based experiences in areas of geological significance as well as to foster international collaboration. Through the gateway of geoheritage sites that have been protected for future use and appreciation, students from all three countries will have educational, fun, and memorable experiences that will hopefully lead from a deeper understanding to a greater appreciation of Earth's heritage and culminate in renewed efforts to protect and conserve our geoheritage.

Project-based learning is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge. The Envirothon uses projects derived from the natural world including a central place for the geological elements. PBL is becoming widely used in schools and other educational settings, with different varieties being practiced. However, there are key characteristics that differentiate "doing a project" from engaging in rigorous project-based learning.

In project-based learning, students work on a project over an extended period of time—from a week up to a semester—that engages them in solving a real-world problem or answering a complex question. In the Envirothon, the problems addressed are developed around the Current Environmental Issues element, which changes each year. The selected issue is meant to integrate the study of different specific elements (geological, biological, and cultural) around an integrated theme that changes each year, such as groundwater protection, watershed management, invasive

species control, and others. The project-based learning in these real-world problems includes working as a team to explore the many facets of current environmental issues and the complexities of real-life decision-making. They demonstrate their knowledge and skills by creating a public product or presentation for a real audience in the regional and final competitions. As a result, students develop deep content knowledge as well as critical thinking, collaboration, creativity, and communication skills. Project-based learning unleashes a contagious, creative energy among students and teachers. PBL requires critical thinking, problem-solving, collaboration, and various forms of communication. To answer a driving question and create high-quality work, students need to do much more than remember information. They need to use higher-order thinking skills and learn to work as a team (www.pblworks.org).

Place-based education (PBE) immerses students in local heritage, cultures, landscapes, opportunities, and experiences, using these as a foundation for the study of language arts, mathematics, social studies, science, and other subjects across the curriculum. PBE emphasizes learning through participation in service projects for the local school and/or community. Envirothon is grounded in the places in which the education and competition take place, starting with the geoheritage elements and extending to the ecosystem and built environment, and how they interact. PBE boosts students' engagement, academic achievement, and sense of personal efficacy as stewards of their local environment and community. It also can re-energize teachers. PBE forges strong ties between local social and environmental organizations and their constituencies in the schools and community, which helps to improve quality of life and economic vitality (www.promiseofplace.org). Using the Envirothon and geoheritage as the gateway to PBE helps foster a conservation ethic among the participating students.

With educational curriculum reform since 2000 in China, students are encouraged to have more project-based learning opportunities and geography field-based experiences. The group at Beijing Normal University has four professors and 28 graduate students that support hundreds of high school programs throughout China. The group helps top high schools to open project-based learning courses nationwide in China and has also organized the Geography Olympiad for high school students and the Environmental Maps Contest for youth in China. The Envirothon is a natural extension of this work and provides enhanced opportunities for international collaboration between the USA and China. The Envirothon starts with a stage of geoheritage and includes the entire cast of the ecosystem and built environment to engage students in both project-based and place-based learning experiences.

Numerous studies have shown the benefits and importance of engaging students in STEM (Science, Technology,

Engineering, and Math)-based education. Just as important are programs that incorporate the environment into the curriculum. Environmental STEM education is at the essence of the NCF-Envirothon program. From the science of geological and ecological systems, to technologies, engineering practices, and mathematical calculations used to determine environmental health or mitigate environmental problems, the Envirothon uses real-life situations to help students learn.

On a broader scale in China, there is a major program underway to identify new national parks and UNESCO Global Geoparks to achieve this goal on a national level. Geoheritage value is a primary determinant of which areas are used for Envirothon field education and competitions; through this gateway, students from both countries will have educational, fun, and memorable experiences. Ultimately, these enjoyable educational experiences in areas of geoheritage value lead to a deeply felt conservation ethic. The US National Park Service recognizes the progression as “through interpretation, understanding; through understanding, appreciation; through appreciation, protection” (Tilden 1957). China’s goal of new national parks and UNESCO Global Geoparks is both a conservation goal and a public engagement goal. Setting aside protected areas can achieve the conservation goal for geoheritage and biodiversity. The public engagement goal depends on effective interpretation and education to build a conservation ethic. The Envirothon can play an important part educating students to foster understanding and appreciation. Understanding and appreciation will help support further conservation.

Declarations

Competing Interests The authors declare no competing interests.

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