UNESCO Global Geoparks as Living Laboratories of Sustainability: From Minoan Heritage to the ESA Mission Zero

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►ABSTRACT

This paper presents an interdisciplinary Green-STEAM educational practice implemented with 23 third-grade primary school students (aged 9) over 30 teaching hours (December 2025-February 2026). Leveraging the two UNESCO Global Geoparks of Crete -Psiloritis and Siteia- as an outdoor classroom, the programme sought to connect geological and intangible cultural heritage with contemporary digital technology. The Rouvas Forest in Gergeri, Heraklio -one of the rarest holm oak forests in Europe and a site of immeasurable ecological and cultural value- served as the central experiential learning space. Students followed three axes of action: (a) experiential visits to the Rouvas Forest and the Eco-museum of Zakros, (b) exploration of Minoan botanical tradition through the eTwinning platform and the Mythspace programme, and (c) analysis of real CO_2 data from the Finokaliá station and the transmission of an environmental awareness message to the International Space Station via ESA Mission Zero. Findings from the reflective survey demonstrated high comprehension rates (92%), a sense of environmental self-efficacy (90%), and a positive evaluation of programming as an expressive tool (86%). The paper discusses how the Geoparks, and especially the Gergeri ecosystem, function as living laboratories of Education for Sustainable Development (ESD), simultaneously cultivating GreenComp and DigComp competences in primary school students.

Keywords: UNESCO Geoparks, Education for Sustainable Development, Green-STEAM, ESA Mission Zero, Greencomp, Digcomp.

►INTRODUCTION

UNESCO Global Geoparks are unique geographic settings in which geological heritage, biodiversity, and human culture coexist in dynamic balance. Their educational value is increasingly recognised in the international literature, both as sites of outdoor learning and as frameworks for developing sustainability competences (Álvarez, 2020; Catana & Brilha, 2020). In Crete, the Psiloritis and Siteia Geoparks represent outstanding examples of this synthesis, offering pedagogical possibilities that extend from natural history to contemporary science and technology.

Among the natural landscapes within the Psiloritis Geopark, the Rouvas Forest in Gergeri, Heraklio, holds a prominent position. It is the largest natural forest of evergreen holm oak (*Quercus coccifera*) in Europe, with trees reaching 15 metres in

height owing to centuries of undisturbed growth. The settlement of Gergeri, at an altitude of approximately 700 metres on the southern slopes of Psiloritis, sustains a living relationship between humans and nature through centuries of livestock farming, agrarian tradition, and botanical knowledge. The combination of geological, biological, and cultural significance makes Gergeri an ideal site for educational experiential visits.

At the same time, European educational policies are turning with increasing emphasis towards two competence frameworks: GreenComp (European Commission, 2022) for sustainability and DigComp (European Commission, 2017, 2022) for digital literacy. The synthesis of both frameworks within an experiential educational practice that uses the natural and cultural landscape as its starting point constitutes the innovative proposal of the present paper.

►BRIEF LITERATURE REVIEW

Research on the role of Geoparks in education has grown significantly over the past decade. Martínez et al. (2023), in a 10-year bibliometric analysis, demonstrated that publications on UNESCO Global Geoparks and education increased by 340% from 2013 to 2023, with dominant themes being environmental awareness, educational tourism, and informal learning. Catana & Brilha (2020) highlighted that Geoparks can function as “living laboratories” for Education for Sustainable Development, particularly when combined with formal educational structures.

In the Greek and Mediterranean context, the educational utilisation of Geoparks remains inadequately researched. However, studies conducted in Geoparks in Spain and Portugal (Álvarez, 2020; Catana & Brilha, 2020) document that the planned integration of visits to natural areas with educational activities significantly increases environmental awareness and commitment to sustainable action. Specifically regarding the Greek Geoparks, the Psiloritis Geopark -the first UNESCO Global Geopark in Greece- and the Siteia Geopark constitute undeniable examples of the coexistence of natural heritage and human activity.

The Green-STEAM approach (Natural Sciences, Technology, Engineering, Arts, Mathematics, with an ecological dimension) is emerging as most appropriate for the holistic development of environmental and digital literacy (Foundation for Environmental Education, 2019; Rantanen et al., 2024). Occhipinti (2025) argues that Geoparks, beyond conservation, constitute tools for scientific research and public engagement, suitable for intergenerational knowledge transfer. Giardino et al. (2022) documented the effectiveness of ERASMUS+ strategic partnerships between Geoparks, schools, and research institutions in strengthening geoeducation.

Within the ESD framework, UNESCO (2017) emphasises the importance of local knowledge as a starting point for understanding global environmental issues. The connection between digital technology and environmental education is considered pivotal, as digital literacy tools such as programming enhance analytical thinking and the ability to process environmental data (Ferrari, 2012; European Commission, 2017).

►PURPOSE, ORIGINALITY, AND SPECIFIC OBJECTIVES

The purpose of this practice is the development of integrated environmental and digital literacy in third-grade primary school students through the utilisation of the

UNESCO Global Geoparks of Crete as “living laboratories” of sustainability, with particular emphasis on the Gergeri ecosystem, Heraklio, and the Rouvas Forest.

The originality of the paper lies in the combined use of: (a) local geological and intangible heritage (Minoan botany, Rouvas Forest, botanical knowledge of Gergeri), (b) contemporary digital tools (Python, Mythspace, eTwinning), and (c) space action (ESA Mission Zero) with the aim of shaping active environmental citizens.

The specific objectives of the practice are: (a) the development of environmental awareness through experiential engagement with the Rouvas Forest and the broader ecosystem of Gergeri, Heraklio, (b) the cultivation of GreenComp competences (understanding sustainability, value commitment, action), (c) the development of DigComp digital competences through programming and data analysis, and (d) the connection of local heritage with global environmental action through the transmission of code to the ISS.

►METHOD

Participants

The programme involved 23 students (12 boys, 11 girls) in the third grade of a primary school in Heraklio, Crete, aged 9. No student had prior programming experience, while 18 of them had visited at least one area of the Psiloritis Geopark at least once; several were familiar with Gergeri from family excursions, a fact that was used as a springboard.

Materials and Procedure

The following tools and platforms were used: (a) Mythspace: an interactive educational platform for connecting mythology and science, (b) eTwinning: a European platform for online student collaboration, (c) Python/Scratch: for introduction to programming and analysis of CO_2 data, and (d) ESA Mission Zero: a European Space Agency programme allowing students to send code to the International Space Station (ESA, 2020–2024). Observation sheets designed by the teacher were used for the experiential visit to Gergeri, while students had tablets at their disposal for photographing and recording biodiversity data on site.

The procedure was organised into three phases: experiential exploration, data analysis, and digital action. Each activity was explicitly mapped to GreenComp and DigComp competences (see Table 1).

Duration

The programme was implemented over 30 teaching hours from December 2025 to February 2026.

Table 1. Detailed structure of the educational programme

Phase / Activity	Setting	Hours	Competences (GreenComp / DigComp)

Introduction to UNESCO Geoparks – Psiloritis & Gergeri	Classroom / Mythspace	6	GreenComp: Environmental awareness
Experiential visit – Rouvas Forest, Gergeri, Heraklio	Outdoor	6	GreenComp: Biodiversity – Place sustainability
Folk botany & Minoan tradition	Classroom / eTwinning	4	GreenComp: Cultural dimension of sustainability
Visit to Siteia Geopark – Zakros Eco-museum	Outdoor	6	GreenComp: Geoheritage – Active citizenship
CO_2 data analysis – Finokaliá station	Classroom / Python	4	DigComp: Data processing – Critical thinking
Programming & ESA Mission Zero (ISS)	Classroom / Python/Scratch	4	DigComp: Digital content creation
Total		**30**	

►DETAILED PRESENTATION OF THE EDUCATIONAL PRACTICE

Axis 1: The Rouvas Forest and Gergeri, Heraklio, as the Central Learning Site

The first phase of the programme focused on experiential engagement with the Rouvas Forest, located in the narrow valley of the Gergeri river, at an altitude of 600-900 metres on the southern slopes of Psiloritis. The forest constitutes one of the rarest ecotypes in Europe: an evergreen holm oak forest (*Quercus coccifera*) with trees of 10–15 metres in height, which have developed undisturbed for centuries owing to the inaccessible geography of the area. The valley is part of the NATURA 2000 network and hosts rare endemic species, such as the Zelkova (*Zelkova abelicea*), a 'living fossil' from the Tertiary period found exclusively in Crete.

During the visit, students were divided into groups of 4–5 and followed three different observation trails. Each group used biodiversity recording sheets on which they noted: (a) plant species with their common and scientific names, (b) traces of fauna (footprints, feathers, insect remains), (c) soil and moisture characteristics, and (d) artistic impressions and aesthetic observations. The teacher accompanied each group in turn, providing explanations and encouraging connections between observations and knowledge from other subjects.

The observation of the Zelkova was of particular pedagogical value: the knowledge that this tree existed millions of years ago and survived in this precise corner of Crete spontaneously triggered discussions about the importance of protecting endemic species. Students created 'biodiversity maps' of Gergeri, both digital and printed, which they later presented to parents and partners via eTwinning.

The Gergeri visit concluded with an educational activity in the village: students spoke with elderly residents about traditional uses of forest plants, collecting oral tradition that was subsequently matched with entries on the "Botanical Treement" platform on eTwinning. This activity practically introduced students to the notion of "intergenerational knowledge" and "intangible cultural heritage" (UNESCO, 2017).

Axis 2: Psiloritis Geopark-Folk Botany and Minoan Tradition

In the second phase, students discovered the intergenerational knowledge embedded in the landscape of Psiloritis. Through Mythspace, they explored the Minoan use of aromatic and medicinal plants, such as dittany (*Origanum dictamnus*), a plant endemic to Crete depicted in Minoan frescoes. Many of the plants they had discovered in Gergeri during the first phase appeared here in Minoan representations, creating a fertile dialogue between on-site observations and historical knowledge.

In collaboration with students from other European countries via eTwinning, the students compiled a digital "Book of Plants" combining scientific terminology with traditional knowledge. Each page contained a photograph from Gergeri or Psiloritis, a scientific name, a Minoan reference, and a contemporary use. This activity strengthened students' sense of identity as inheritors of a living tradition.

Axis 3: Siteia Geopark and Digital Action

The third phase combined experiential visits to the Zakros Eco-museum and the archaeological sites of the Siteia Geopark with high-engagement technological activities. Students analysed real CO_2 data from the Finokaliá atmospheric station, using Python for simple graphical representations and comparison of values from different years.

The culmination of the programme was participation in ESA Mission Zero: students wrote code in Python to measure CO_2 data on the International Space Station (ISS) and send an environmental awareness message inspired by the landscape of Gergeri, the holm oaks of Rouvas, and Siteia (ESA, 2020–2024). The students' message -"From the Gergeri Forest to the International Space Station: we protect what we love"- symbolically encapsulated the entire pedagogical journey.

►RESULTS AND EVALUATION

Programme evaluation was based on a 5-point Likert-scale reflective questionnaire completed by all 23 students at the end of each phase. Results (see Table 2) demonstrate high rates of positive experience across all axes.

Table 2. Student reflective survey results (n = 23)

Reflective Statement	Agree / Strongly agree	Neutral / Disagree
I understood the importance of Geoparks for the environment	92%	8%
I feel capable of contributing to environmental change	90%	10%
Programming (Python/Scratch) helped me express my ideas	86%	14%
The visit to the Rouvas Forest / Gergeri changed the way I see nature	91%	9%
I would like to visit Gergeri or another Geopark again	95%	5%

Average	**90.8%**	**9.2%**

The quantitative data were reinforced by qualitative observations: students spontaneously expressed feelings of “mission” when transmitting code to the ISS and of “discovery” during the Gergeri visit. Strikingly, 95% expressed a wish to revisit Gergeri or another Geopark, indicating deep emotional engagement with the place.

►DISCUSSION

The results confirm the central hypothesis that UNESCO Global Geoparks can function as effective “living laboratories” of ESD for primary school students (Álvarez, 2020; Catana & Brilha, 2020). The visit to Gergeri, Heraklio, and the Rouvas Forest proved particularly catalytic: direct contact with one of the rarest holm oak forests in Europe generated a deeper and more lasting emotional commitment than any narrative or digital presentation.

The combined GreenComp-DigComp approach proved applicable to 9-year-old students, a finding that extends the existing literature, which focuses mainly on older age groups. The integration of ESA Mission Zero as the culmination of the practice proved catalytic for engagement: the sense of a ‘real mission’ functioned as a powerful motivator (90% self-efficacy), in agreement with findings from STEM Engagement programmes (NASA, 2020–2024).

The connection of local identity -the Gergeri Forest, Minoan botany, the intergenerational knowledge of its residents- with space action is not merely a pedagogical strategy but a principle: students engage more deeply when their action is rooted in a place they love. This “sense of place” as an engagement mechanism is consistent with the theory of Education for Sustainable Development (United Nations, 2015; UNESCO, 2017).

However, certain limitations were also noted: access to the Siteia Geopark required considerable organisational effort, while students’ varying familiarity with digital tools created inequalities during the programming phase that needed to be addressed through differentiated instruction.

►CONCLUSIONS

This educational practice demonstrates that the UNESCO Global Geoparks of Crete, and in particular the landscape of Gergeri, Heraklio, with the Rouvas Forest, offer a unique framework for the integrated cultivation of sustainability and digital literacy competences in primary school students (Cycles A’/B’). The Rouvas Forest, as one of the few truly undisturbed natural ecotypes in Europe, is not simply a school “educational resource”-it is a place that speaks directly to young people about the relationship between humanity and nature, about time and endurance, about what it means to protect what one loves.

The connection of local heritage -from Minoan botany to the centuries-old holm oak and the living memory of Gergeri’s residents- with contemporary space technology is not merely a pedagogical device but a substantive pedagogical principle: knowledge acquires meaning when it has roots and a horizon.

The high rates of comprehension (92%), environmental self-efficacy (90%), and desire to repeat the experience (95%) suggest that this approach can serve as a model

for similar practices in other Geoparks in Greece and Europe. Future research could examine the long-term effects on the formation of environmental identity, as well as the extension of the model to older age groups and different Geoparks.

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