

Perspective

The Blue School Program: A Model for Holistic Ocean Literacy Education

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Abstract: The Blue School Program is an educational initiative to enhance ocean literacy (OL) by fostering understanding and awareness of the ocean's importance among students, teachers, and local communities. Through a holistic, interdisciplinary, and intercultural approach, it integrates scientific, cultural, and ethical dimensions of ocean education. This perspective paper examines the program's implementation in Portugal, emphasizing its contribution to crucial educational domains such as sustainability education, scientific literacy, and citizenship education. The findings highlight notable achievements, including increased school and community engagement and the establishment of robust public-private partnerships, while also addressing challenges such as resource constraints and geographic disparities. By situating the Blue School Program within broader educational frameworks and analyzing its limitations and enablers, this paper offers insights and recommendations to support the collaborative development of Blue School networks and OL initiatives in diverse educational contexts.

Keywords: ocean literacy; holistic education; Blue School program; ESD; scientific literacy; citizenship education; interdisciplinary learning



Academic Editors: Marcos García Alberti, Fernando Suárez Guerra and Juan Carlos Mosquera Feijoo

Received: 18 November 2024

Revised: 12 December 2024

Accepted: 16 December 2024

Published: 16 January 2025

Citation: Costa, R.L.; Faria, C. The Blue School Program: A Model for Holistic Ocean Literacy Education. *Sustainability* **2025**, *17*, 661. <https://doi.org/10.3390/su17020661>

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1. Introduction

The ocean is a vital ecosystem, serving as a nurturing environment for life, a critical climate regulator, and a source of marine compounds with significant medical potential [1,2]. It also offers economic opportunities and cultural enrichment [3]. However, human behavior often fails to reflect the ocean's importance, with perceptions of the ocean as an infinite resource or 'too big to fail' diminishing individual responsibility [4]. This mindset can lead to apathy fueled by negative media and scientific discourse on environmental sustainability [5,6]. Two decades ago, a collaborative effort in the USA, led by Cava et al. [7], aimed to integrate ocean-related content into K-12 science curricula, marking the genesis of the ocean literacy (OL) movement. This movement introduced seven principles to integrate ocean topics into the National Science Education Standards [7], providing educators with guidelines and resources to infuse ocean-related content into science lessons across all grade levels.

Over time, this movement gained global attention, forming ocean literacy networks, such as the European Marine Science Educators Association (EMSEA) in 2011 [8]. The Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) [9] significantly advanced the field by establishing ocean literacy as a multiperspective approach to education for sustainability. This approach encompasses scientific aspects and elements such as history, geography, gender equality, culture, values, and sustainability.

Ocean literacy was first defined as understanding the ocean's influence on us and our influence on the ocean [9]. It involves knowledge and awareness, transforming this scientific knowledge into actions for a sustainable ocean. The evolution of ocean literacy has led to a holistic view, encompassing a broader understanding of the ocean's role in shaping human societies, cultures, economies, traditional knowledge, and well-being [8].

Efforts are now being made to make ocean literacy more inclusive and accessible by incorporating diverse cultural perspectives and traditional knowledge [8,9]. Furthermore, initiatives such as citizen science projects are essential for engaging culturally related and frequently overlooked local or regional contexts [10–12].

Recently, the IOC-UNESCO released a support document [13] providing tools for decision-makers and guidelines for curriculum developers to facilitate the integration of ocean literacy into formal education globally. The United Nations Decade of Ocean Science for Sustainable Development (2021–2030) [14] presents a unique opportunity to demonstrate the importance of ocean literacy, particularly in the educational sector.

Integrating ocean literacy into schools to achieve systematic change in students, active citizens, and decision-makers involves challenging educational design. Translating knowledge into concrete actions, empowering students, making them responsible citizens, and fostering emotional connections with the ocean are essential yet challenging objectives. Positive and lasting changes require time and are influenced by an individual's culture, values, education, and life experiences [9,15,16].

Incorporating ocean literacy into the school curriculum is vital for increasing awareness and knowledge about ocean sustainability [1,17]. However, authors of [18–20] argue that ocean literacy should be integrated through a whole-school approach, emphasizing the need for collaboration between formal (school-based) and informal (community-based) education systems to bridge gaps in ocean literacy and improve integration into school curricula. This approach highlights connections with education for sustainable development, scientific literacy, and citizenship, providing valuable insights into how ocean literacy contributes to contemporary education [21–24]. Despite numerous ocean literacy projects in educational contexts, many initiatives require continuity and a clear ocean literacy framework. Most existing projects are short-term and do not provide sustained engagement or systemic integration into the whole-school approach [25]. This gap underscores the need for well-structured and long-lasting programs to incorporate ocean literacy into the educational system effectively, ensuring students develop a lasting understanding and commitment to ocean sustainability [16].

This manuscript explores the historical and cultural context of ocean literacy in Portugal, highlighting the development of the Blue School Program and its alignment with educational and sustainability goals. It examines the program's structure, key components, and implementation while also presenting its growth, geographic reach, and stakeholder engagement. The discussion addresses challenges and opportunities for further scaling the program, and the conclusion reflects on its contributions and potential for advancing ocean literacy education globally.

2. Crossing Ocean Literacy: Portugal's Approach and Journey

Despite Portugal being a nation where the ocean is deeply ingrained in its culture, there is still a lack of awareness about the interdependency between people and the sea [26], even after two decades of focused efforts in ocean literacy (OL) and environmental education, particularly within the school context. Barracosa [27] notes that Portugal was one of the first countries in Europe to implement ocean literacy educational projects. Due to its geographical location and maritime culture, many formal and informal educational programs included sea-related activities even before the introduction of OL. Environmen-

tal interpretation centers, NGOs, companies, science centers, museums, and aquariums developed ocean literacy activities for schools, primarily focusing on scientific literacy, environmental education, and science communication.

Portugal pioneered translating and adapting the ocean literacy principles to suit the Atlantic context. This initiative, led by *Ciência Viva* in 2011 [9], represented significant progress toward integrating ocean literacy into formal education without changing the national curriculum. Efforts were made to align ocean literacy principles with existing science and geography programs across all grade levels. Despite these efforts, including ocean-related topics in classrooms remained sporadic.

Documents such as the National Strategy for the Sea 2013–2020 and 2020–2030 [28,29] mention OL, but Portugal still lacked a concrete ocean literacy strategy in public policies from 2020 to 2023 [30].

Blue Schools emerged from discussions in European marine education forums during the mid-2010s, where ocean literacy experts expressed interest in engaging schools with ocean-related themes. In Portugal, it was recognized that this initiative could provide a robust solution to enhance ocean literacy in school contexts. With the support of the Ministry of the Sea, a national working group outlined the Blue School program, which was launched as a pilot in 2017 (Figure 1). The first Blue School National Meeting was held in 2018, and in 2020, during the pandemic, the first Blue School Day challenge was launched in Portugal.

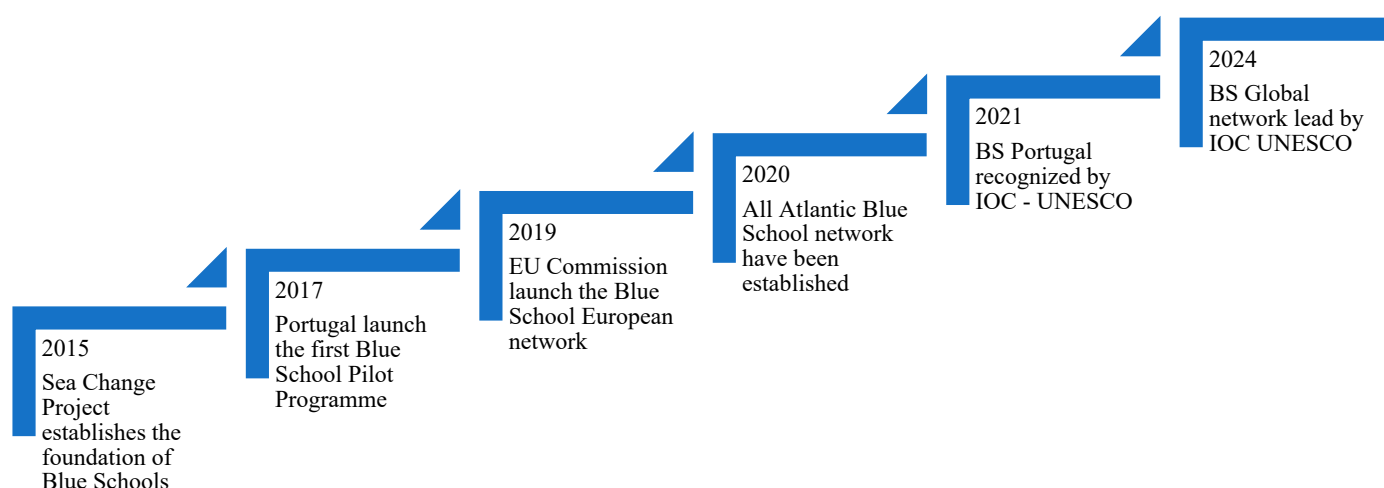


Figure 1. Blue School timeline.

Following the initiative's success in Portugal and its recognition by the Intergovernmental Oceanographic Commission (IOC), the European Union decided in 2019 to establish a European Blue Schools network. The EU provided financial support to create the network, aiming to foster a coordinated and impactful approach to improving ocean literacy on a larger scale [31].

In 2020, Argentina and Brazil launched their Blue School pilot programs on the other side of the Atlantic as part of the All-Atlantic Blue Schools Network, an initiative to promote ocean literacy throughout the Atlantic region. By 2021, 15 additional Atlantic countries joined the network, significantly expanding the reach and impact of Blue Schools across both sides of the ocean [32]. By 2024, IOC-UNESCO had created the Blue Schools Global Network (Figure 1), paving the way for other interested countries to join this global movement. The Blue School program is not unique in its efforts to promote ocean literacy in education. Other notable initiatives include the Ocean Guardian School Program in the United States [33], and Canada's Ocean School, which use immersive technologies and hands-on conservation projects to promote ocean literacy [34]. France's Aires Marines

Educative (AME) initiative involves students managing and protecting small marine areas, emphasizing local stewardship [35].

This study critically examines the Blue School Program, focusing on its contributions to advancing ocean literacy as a transformative framework for sustainability education. While ocean literacy is inherently linked to Sustainable Development Goal SDG 14 (Life Below Water), its interdisciplinary nature enables it to address broader educational and social challenges, aligning with multiple Sustainable Development Goals (SDGs). By fostering critical thinking, community engagement, and environmental stewardship, ocean literacy empowers schools, educators, and communities to contribute to sustainability beyond the ocean actively, creating pathways to achieve SDG 4 (Quality Education) and SDG 17 (Partnerships for the Goals).

Using a qualitative, exploratory approach, this study draws on data from 104 certified Blue School projects, institutional partners, and observations from collaborative meetings to analyze how the program integrates ocean literacy principles into educational practices. The analysis highlights the program’s structured criteria (Table 1), which serve as a lens to evaluate its impact on ocean literacy, its alignment with broader sustainability goals, and its potential for adaptation in diverse contexts.

Table 1. Blue School criteria explanation and related learning strategies, outcomes, and education domains.

Blue School Criteria	Criteria Explanation	Learning Strategies	Expected Learning Outcomes (Knowledge, Skills, and Attitudes)	Relevant Education Domains
Explores an ocean topic in an interdisciplinary way	The project should consider an ocean topic that is relatable to real-life situations relevant to students’ daily lives (local or global).	Problem-Based Learning (PBL): Presenting students with real-world problems, encouraging them to explore and solve problems through critical thinking and application of knowledge [36,37].	Cognitive learning, critical thinking, reasoning, and scientific inquiry skills [37–42].	Ocean literacy [43], Science literacy, Education for Sustainable Development, and Citizenship Education [44,45].
Select Blue School ambassadors	Designate at least two students as ambassadors, empowering them to communicate the school project actively.	Active Participation, Critical Thinking [38,40].	Communication and negotiation skills, environmental advocacy [44], citizenship, and social responsibility [16,45].	Ocean literacy, Education for Sustainable Development [46], Citizenship Education.
Engages students of different grades	Engage students across different grades.	Collaborative Learning: Fostering group work and student collaboration to promote peer interaction and shared learning experiences [45,47].	Cooperative learning, leadership, and empathy among students [47].	Citizenship Education [44].

Table 1. *Cont.*

Blue School Criteria	Criteria Explanation	Learning Strategies	Expected Learning Outcomes (Knowledge, Skills, and Attitudes)	Relevant Education Domains
Communicates its actions	Communicate ocean-related actions within the school and local community.	Cooperative Learning: Structuring activities require students to work together to achieve common goals and shared responsibility [47].	Communication, creativity, and collaboration skills [45].	Ocean literacy, Citizenship Education.
Interacts with the partners' network	Establish connections and interactions with stakeholders while implementing their educational project. This will bring the school community closer to the maritime sector, ocean science, blue professions, conservation, and marine protection.	Active Learning encourages students to actively participate in the learning process through discussions and hands-on experiences [48]. Inquiry-based learning enables students to ask questions, investigate, and explore solutions, promoting curiosity and self-directed learning.	Problem-solving and critical thinking, career readiness [40].	Ocean literacy, Education for Sustainable Development, Citizenship Education.
Involves the local community	Extend the school project beyond the school boundaries, establishing connections with families, friends, and the broader community to ingrain ocean literacy in the local community.	Cooperative Learning: Structuring activities that require students to work together to achieve common goals, promotes teamwork and shared responsibility [39,48].	Communication skills, cultural competence, citizenship, and social responsibility [47,49].	Education for Sustainable Development, Citizenship Education.
Encourages students to be active	Stimulate students to transform knowledge into action, promoting active intervention in school and the local community or partnerships with NGOs, municipalities, or other civil groups.	Active Learning encourages students to actively participate in the learning process through discussions [50,51] and hands-on experiences. Inquiry-based learning encourages students to ask questions, investigate topics, and explore solutions, promoting curiosity and self-directed learning [52,53].	Social activism, communication skills, advocacy, adaptability [54].	Ocean literacy, Citizenship Education.

Two central questions guide this study:

- How does the Blue School Program structure and implement ocean literacy within the school context, and what criteria drive its success?

- How can lessons learned from the Portuguese experience inform adaptations of the program in other geographical and cultural contexts to maximize its impact on sustainability education?

Beyond examining the program's implementation in Portugal, this study positions the Blue School Program as a global model for advancing sustainability education. Integrating interdisciplinary strategies, actionable insights, and practical recommendations aims to inform policymakers, educators, and administrators about how ocean literacy can act as a catalyst for achieving diverse sustainability objectives across educational systems.

3. Blueprint for the Blue School Program

The Blue School is a national educational program endorsed by the Portuguese Ministry of Economy and Maritime Affairs. It aims to enhance ocean literacy in schools and develop responsible and engaged generations committed to the sustainability of the oceans. The program also seeks to establish a network that brings schools, local communities, and the blue economy sector closer together [55].

3.1. The Blue School Network Structure

The Blue School Coordination implements and assesses the program (Figure 2).

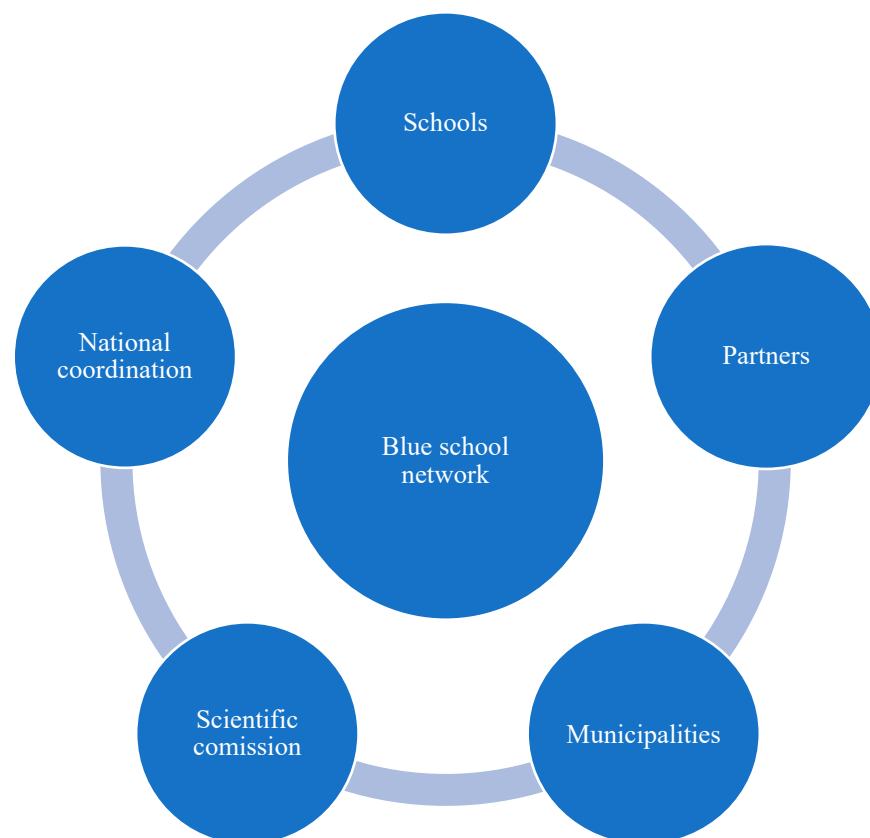


Figure 2. Principal stakeholders of the Blue School network.

Its primary tasks include establishing a network of partners and municipalities, managing program communication, evaluating applications, and monitoring school projects. Additionally, it organizes national events and conducts follow-up regional meetings with schools.

The Scientific and Pedagogical Commission (SPC) comprises various entities that collaborate in evaluating Blue School applications, participate in regional and national

meetings, and provide advisory support on conceptual and structural issues related to the program.

The core of the BS network consists of the participating schools. These schools incorporate ocean-related projects into their activities, encouraging the school community to understand the ocean's influence on us and our impact on the sea. The Blue School Coordinator Teacher is pivotal, overseeing the application process and motivating colleagues to participate. These teachers lead the project while other team members engage students, promoting civic, active, conscious, and responsible participation.

Partners offer ocean-related educational activities, including field trips, lectures, and project development. They are invited to regional meetings to present and share their activity proposals with the schools.

Municipalities also play a supportive role by guiding local schools and identifying local entities to join the Blue School Partners' network. They support program communication at the regional level and participate actively in regional meetings, ensuring alignment between local community needs and educational initiatives.

3.2. BS Ocean Literacy Framework

The Blue School program's framework integrates ocean literacy principles with a holistic perspective (Figure 3). Developed by the US Ocean Literacy Network in 2005, these principles aim to enhance public understanding of the ocean's influence on humans and vice versa [7]. This new adaptation combines the ocean literacy principles with the holistic perspective adopted by Education for Sustainable Development (ESD) and translated to the ocean context by [9].

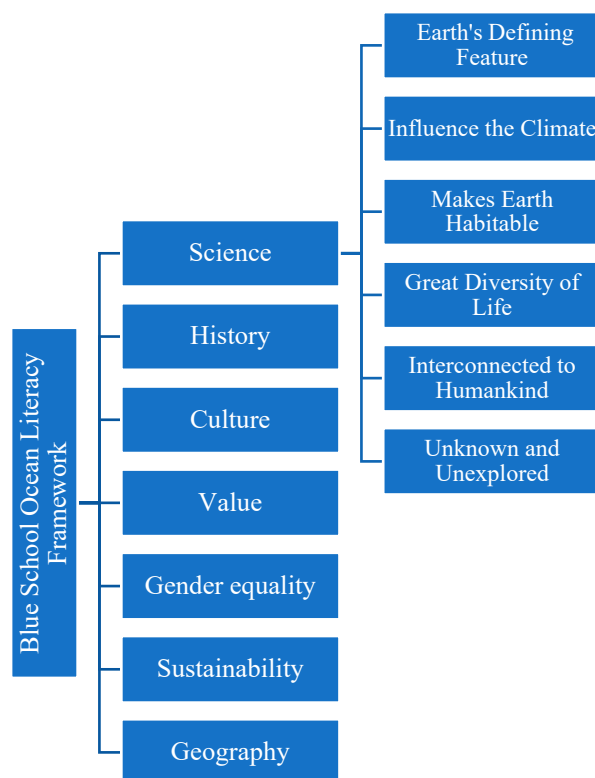


Figure 3. Ocean literacy approach for Blue Schools.

To develop the pedagogical model for the Blue School Program, the objectives and expected societal outcomes of the United Nations Decade of Ocean Science for Sustainable Development were integrated with the targets outlined in the Agenda 2030 Sustainable Development Goals, specifically Goals 4 (Quality Education), 14 (Life Below Water), and 17

(Partnerships for the Goals). National documents were also used, including the National Ocean Strategy [29] and the Education Guidelines issued by the National Ministry of Education [43,56].

These foundational concepts are translated into specific criteria that schools must meet to be recognized as Blue Schools. The criteria tentatively ensure a broad approach to ocean literacy, integrating interdisciplinary topics, promoting active participation, and engaging with the local community.

3.3. Blue School Official Recognition

To become a Blue School, a school must first apply for official recognition by submitting a project for evaluation. The project must fulfil seven out of the eight required criteria. If necessary, the Blue School (BS) Coordination helps the school structure, adjust, or redefine its proposal. This includes finding suitable partners, outlining objectives, and defining creative strategies to achieve all criteria. The coordination team never outright rejects submissions; instead, they assist schools in making necessary adjustments until the application meets the standards (Figure 4).

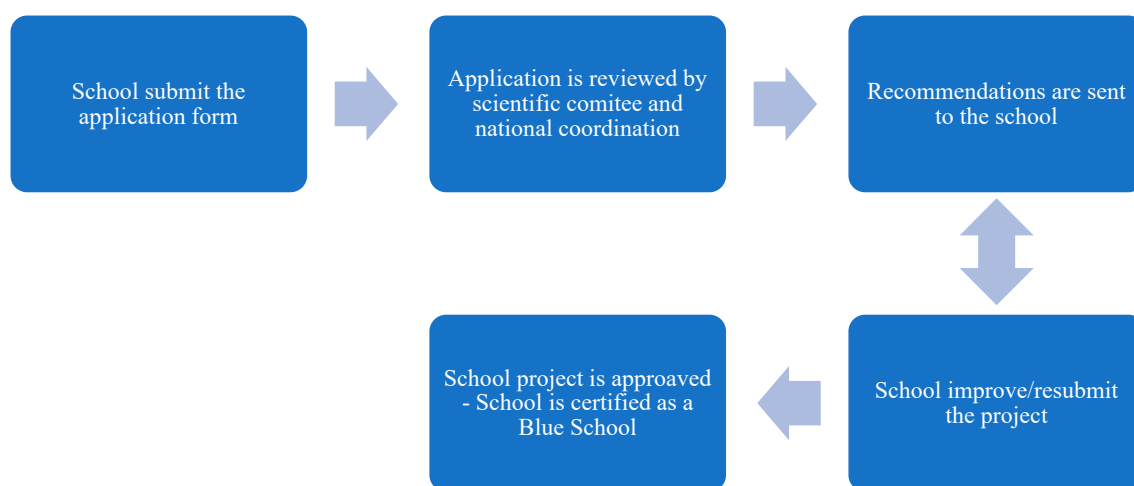


Figure 4. The recognition process for Blue Schools.

Once the application is well structured, the Scientific and Pedagogical Commission performs the final review. Entities involved in the review are chosen based on the primary topic addressed by the school and their geographical location.

Upon acceptance, the school receives a welcome kit and begins implementing its project. The school will be part of the Blue School network for the next two years. During this period, schools must interact with other schools and participate in ocean literacy initiatives. This includes celebrating Blue School Day, where all schools respond to the annual challenge. For example, a human chain showing the willingness to protect the ocean, which involved more than 350 schools, local communities, and partners from various municipalities across the country, drew the attention of policymakers and the media in support of ocean preservation.

Most importantly, the regional meetings between teachers, the scientific commission, and the coordination team are where the academic year's successes and significant challenges are shared (Figure 5).

By integrating ocean literacy into the school curriculum and promoting community involvement, the program aims to provide students with opportunities to become more informed, responsible, and proactive. While previous studies have explored ocean literacy as essential for understanding ocean issues and human-ocean interactions, limited research has focused on scientifically assessing large-scale programs like the Blue School.

Although now being adapted for international use, the Blue School Program has not yet been thoroughly studied, leaving a gap in understanding its effectiveness and adaptability in promoting ocean literacy in educational contexts. This study seeks to address this gap by providing a comprehensive analysis of the Blue School Program, examining its alignment with the current definition of ocean literacy and evaluating its educational outputs using established educational frameworks.

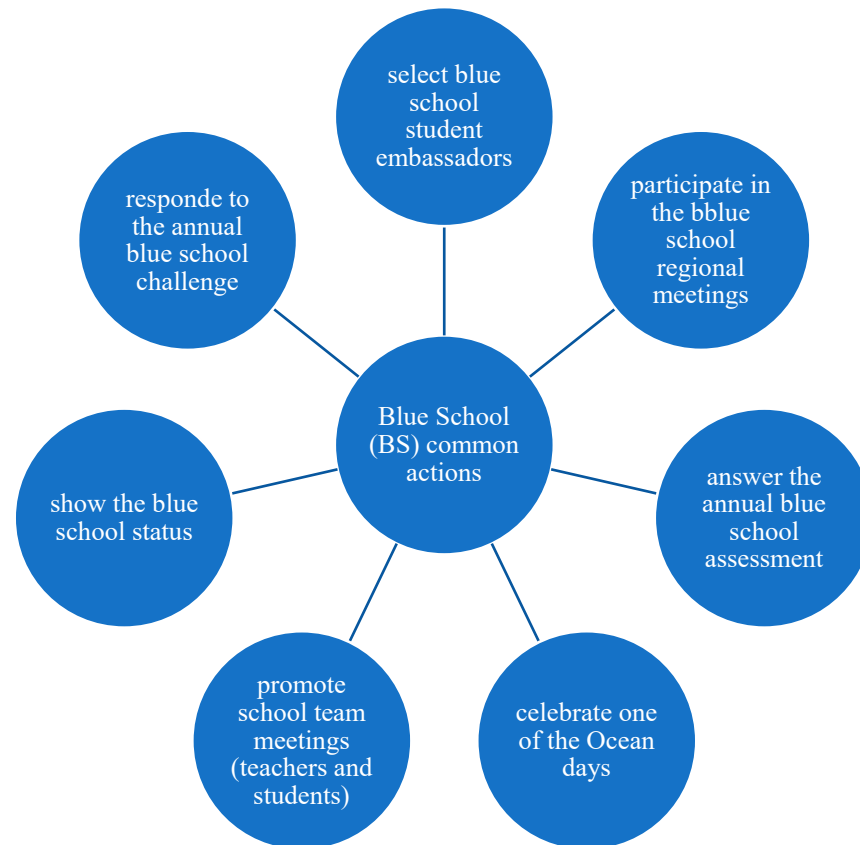


Figure 5. Schools' responsibilities and mandatory actions.

4. Materials and Methods

This study employs a qualitative, exploratory approach, utilizing data from the Blue School databases, school application forms, and responses from targeted questionnaires. These data sources provide a descriptive basis for understanding the structure of the Blue School Program, its alignment with ocean literacy principles, and its role in fostering interdisciplinary, multiperspective approaches in educational contexts.

Insights into the educational practices promoted by the program were drawn from qualitative data collected through school application forms, teacher questionnaires, and school visit observations. These sources reflect teachers' and schools' perspectives and reported practices, providing a foundation for understanding how the Blue School Program supports engagement with ocean literacy principles. While not direct measures of student learning or behavioral outcomes, these data offer valuable information about the program's implementation and its potential to shape educational experiences.

The primary data included 104 application forms submitted by Blue School teacher coordinators through the program's official website until 2022. These forms detail how schools meet the Blue School criteria, providing a comprehensive view of the program's structure and outreach. Due to her role as the program coordinator, the researcher was granted access to the Blue School databases, managed by the Directorate-General for Maritime Policy (DGPM). These databases contain detailed information about participating

schools and partner entities for 2021, 2022, and 2024, offering insights into the socio-geographic contexts of schools and their engagement with the program.

The schools were classified by proximity to the coast (as “coastal” or “inland”) and community type (urban, rural, or coastal). Descriptive statistics were used to summarize program engagement levels, teacher and student participation, alignment with ocean literacy principles, and the program’s structured criteria implementation.

Targeted questionnaires were emailed to Blue School teacher coordinators, yielding 248 responses. Of these, 113 responses were considered valid based on exclusion criteria, which included lack of consent, incomplete identification of the school or municipality, and responses with less than 50% of questions answered. All data analyzed in this study reflect information from the 2022 program cycle.

A thematic content analysis was conducted to analyze textual data extracted from school application forms and teacher questionnaires. This analysis employed an open coding approach, identifying key themes reflecting how schools engage with ocean literacy principles and implement interdisciplinary educational strategies. The key themes identified include:

- Alignment with ocean literacy principles and multiperspective approaches.
- Implementation of interdisciplinary educational approaches, such as Problem-Based Learning (PBL) and Inquiry-Based Learning (IBL).
- Levels of community and stakeholder engagement in school projects.

This approach provided a structured framework for examining how schools conceptualize and incorporate ocean literacy principles into their activities, offering insights into the program’s alignment with its educational goals.

Data on the professional experiences of program coordinators were also documented through notes taken during regional meetings held in 2020, 2021, and 2022. These notes provide additional qualitative insights that support the discussion and contextual analysis presented in this article.

5. Results

5.1. Evolution and Growth of the Blue Schools Network

The Blue School Program has consistently grown across all metrics over the years. This sustained growth suggests its ability to attract and retain the interest of students, schools, and stakeholders.

Notably, the 2021/22 academic year, which followed the height of the COVID-19 pandemic, stands out with a high increase in engagement and participation. During this period, the number of students engaged more than doubled compared to the previous year, rising from 32,000 to 68,518, representing a growth of approximately 114%. Similarly, Blue Schools increased by 31%, from 235 to 307 (Figure 6). This surge is linked to two main factors: the resumption of in-person activities, a renewed focus on educational and environmental programs, and the establishment of regional coordination in Madeira, which led to significant growth in that region.

The increase in stakeholder initiatives starting from the 2020/21 academic year suggests strengthening partnerships and greater collaboration between schools and local communities. This growth can be attributed to the consolidation of the program and the launch of funding opportunities for entities to develop projects for Blue Schools. These funding initiatives have likely mobilized external resources and increased community involvement in achieving the program’s objectives.

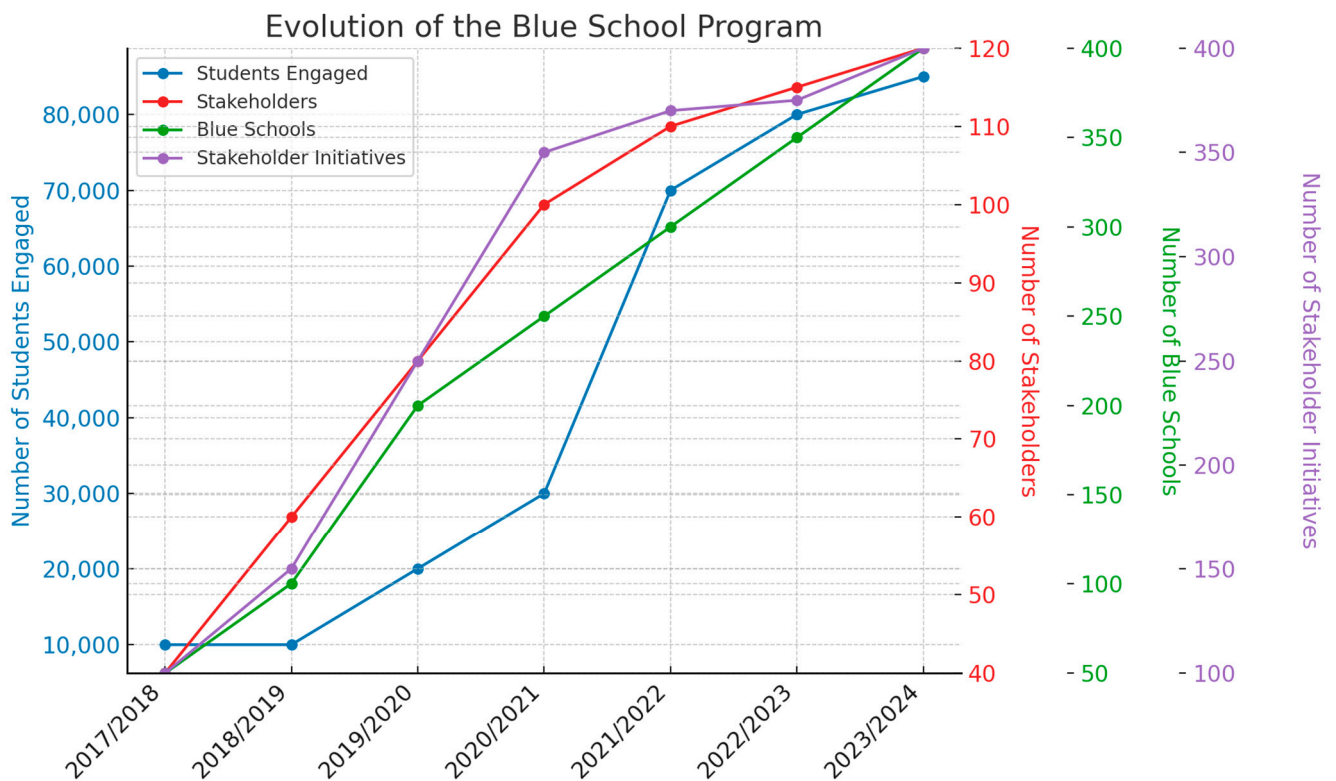


Figure 6. Evolution of the Blue School Program over the academic years from 2017/2018 to 2023/2024.

5.2. Geographic Distribution of Blue Schools

The Blue School Network is distributed across various geographic areas, each with unique characteristics that influence the implementation of Blue School projects. The distribution of schools is illustrated in the graphs below (Figure 7).

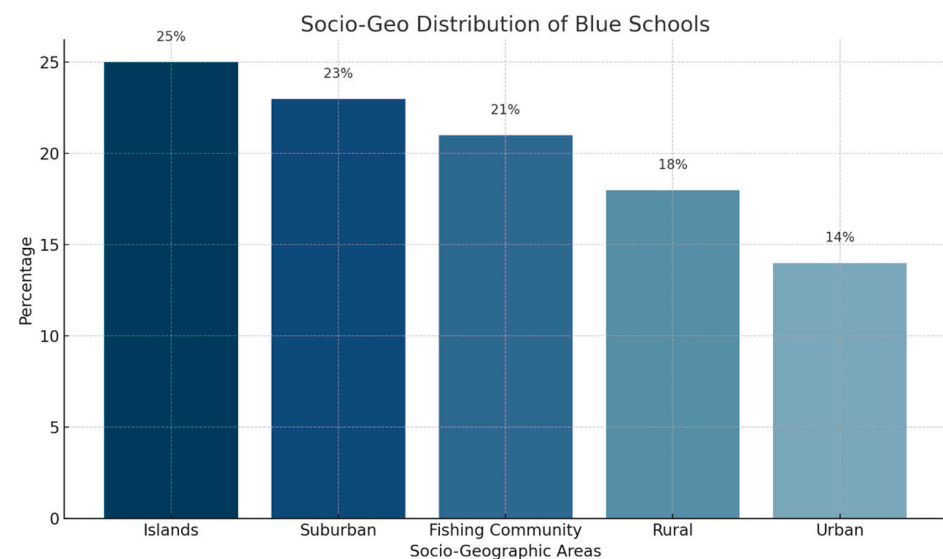


Figure 7. Geographical and social distribution of the Blue Schools in Portugal.

Rural areas comprise 17.8% of the network and are regions with low population density, usually distant from large urban centers. They can include small villages, hamlets, and agricultural areas. Despite logistical challenges, these schools foster a solid connection to nature and marine conservation. Additionally, due to the close-knit nature of these communities, families are often more available to participate in projects, and teachers

and students have stronger relationships with each other and local entities, facilitating collaboration in projects.

Fishing communities represent 20.8% of the Blue Schools. These localities, where fishing is a primary economic activity, can include villages or small coastal towns. Although the blue economy is intrinsic to these communities, schools rarely choose fisheries or sustainable fish consumption as themes for their projects, often covered in geography. Instead, they frequently select topics like marine pollution and conservation, focusing on projects more directly aligned with citizenship and physical–chemical and biological sciences curricula.

Urban and suburban areas, comprising 37% of the school network, are regions with high population density and developed infrastructure. These include large cities with a wide variety of services and economic activities. These schools have access to various partners, science centers, and museums.

Islands make up 24.8% of the network. They are insular regions with direct access to marine resources, facilitating hands-on ocean literacy activities.

5.3. Distribution Across Educational Levels

The Blue School network includes a variety of educational levels, reflecting broad engagement across different stages of student development. Figure 8 shows the distribution of Blue Schools by academic level.

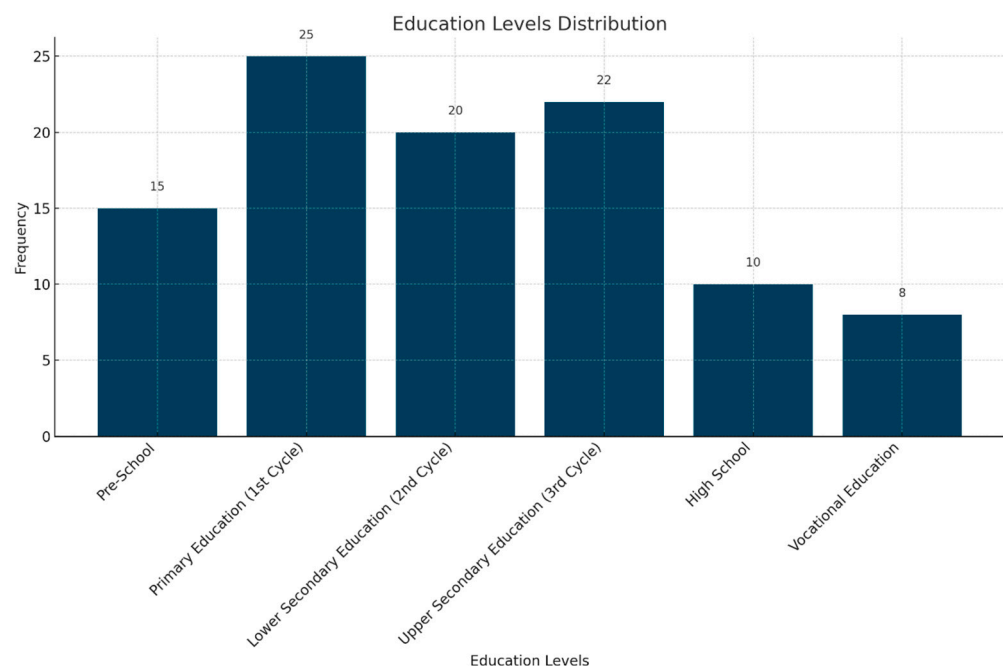


Figure 8. Distribution of Blue Schools by educational level.

Pre-school institutions account for 18.0% of the network, focusing on foundational learning and development for young children. Primary education schools represent the largest group, comprising 24.3% of the primary education network. This high proportion at the primary education level is due to the greater curricular flexibility at these levels, where elementary schools have more latitude in incorporating ocean literacy projects into their curricula. Lower Secondary Education schools make up 19.1% of the network, providing more advanced education that builds upon primary education.

Upper Secondary Education institutions account for 20.9% of the Blue School network, preparing older students for higher education or vocational training (Figure 8). High Schools represent 10.5%, focusing on advanced secondary education to prepare students

for college, university, or the workforce. The lower representation at the secondary level might be due to the emphasis on standardized exams, limiting teachers' ability to engage in extra projects that could divert focus from exam preparation. Lastly, Vocational Education institutions constitute 7.2% of the network, offering specialized training and education for specific trades and professions.

Figures 9 and 10 illustrate the results of a content analysis of projects submitted by teachers within the Blue School network, examined through the lens of ocean literacy principles and the ocean literacy multi-perspective approach. These figures visually represent the frequency and distribution of different themes and ocean literacy principles addressed in the projects, highlighting their alignment with the program's goals.

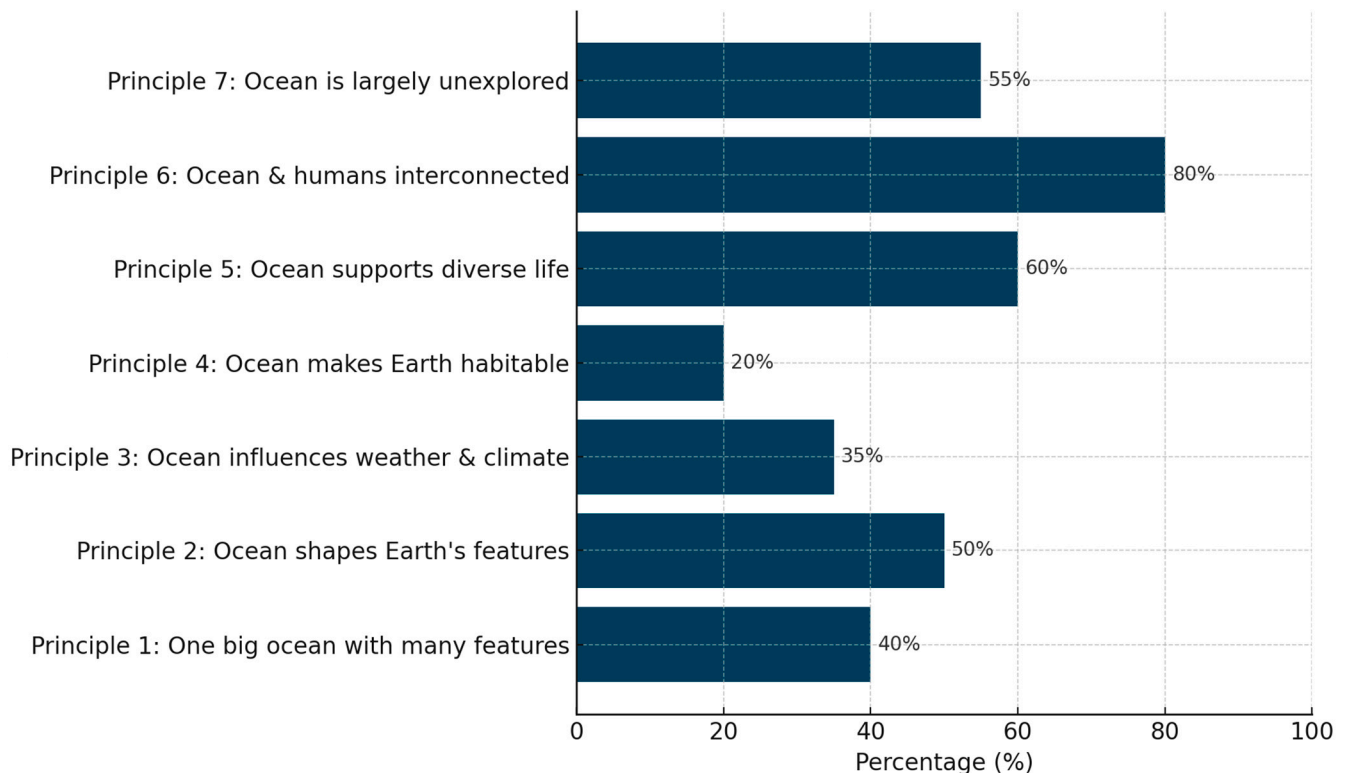


Figure 9. Distribution of ocean literacy principles in Blue Schools. Analysis of dominant principles in teacher-submitted projects.

Figure 9 shows the integration of ocean literacy principles across the projects, with particular emphasis on Principle 6, which relates to the interconnection between the ocean and humans, and Principle 5, which highlights the diversity of life and ecosystems in the ocean. This figure reflects how teachers prioritize specific ocean literacy principles in their project designs.

Figure 10 displays the distribution of projects according to a multiperspective ocean literacy approach, with a primary focus on sustainability, science, and culture as prominent themes. Additional themes, such as geography, values, and history, are also represented, indicating the perspectives addressed in the Blue School projects. These data demonstrate the variety of thematic approaches schools in the network apply to foster ocean literacy, integrating multiple disciplinary perspectives within the educational activities.

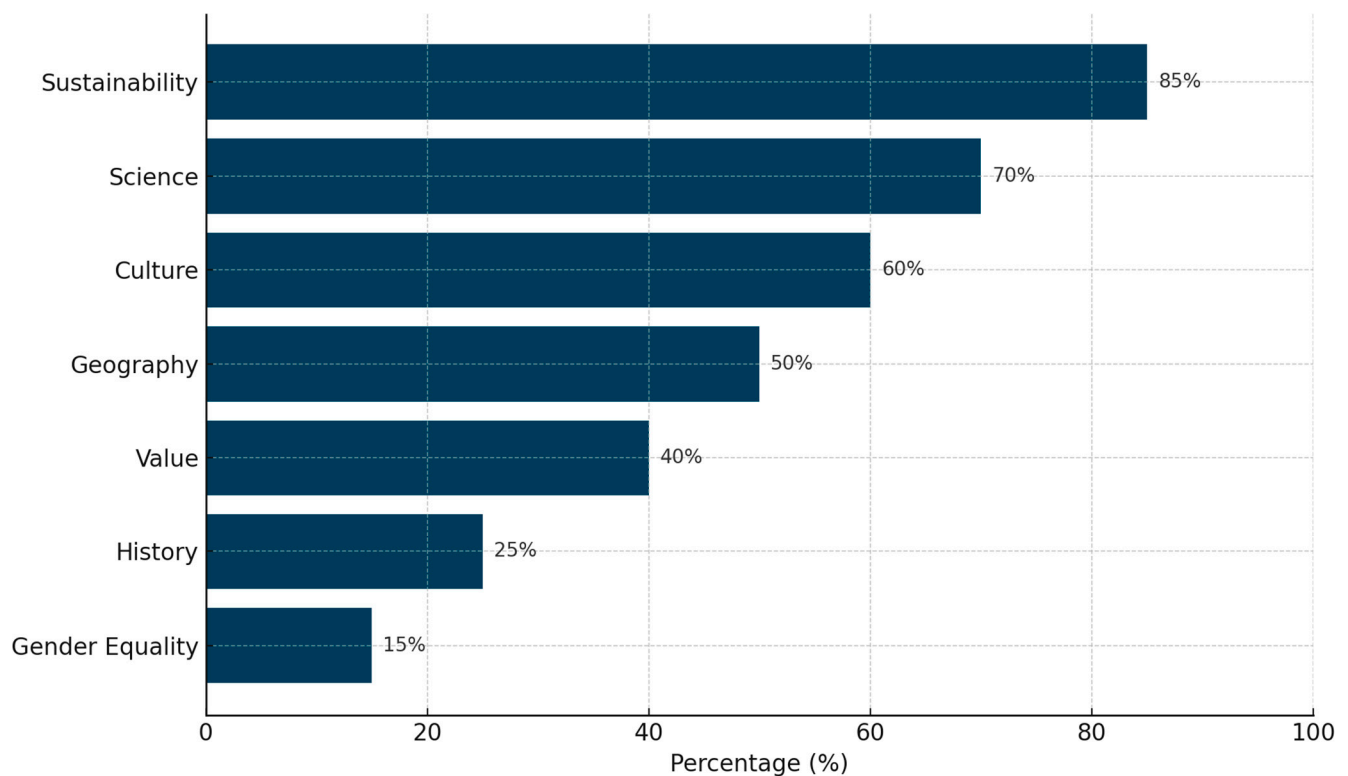


Figure 10. Ocean literacy perspectives in Blue Schools. Analysis of dominant themes in teacher-submitted projects.

5.4. Diversity of Partners

The Blue School network includes diverse partners categorized based on their primary activity. Companies represent the most significant portion, comprising 33.6% of the organizations in the network. This is followed by non-profit associations, which account for 18.5%, and public entities, which comprise 14.3% of the partners. Museums and Zoos contribute 13.4% to the network, while Universities and Research Centers represent 7.6%. NGOs and Projects account for the most minor portions, with 5.9% and 6.7%, respectively (Figure 11).

Companies often provide educational resources and expertise for educational programs and create initiatives. They also offer internships for students. Non-Profit Associations typically focus on providing educational content and developing initiatives for schools. They play a crucial role in raising awareness within school communities. Public Entities, including local and national government agencies, often facilitate access to public resources and help integrate Blue School initiatives into broader educational or cultural frameworks. Museums and Zoos serve as educational partners, offering unique learning environments and programs related to marine biology, conservation, and environmental science. They provide hands-on learning experiences and host special events. Universities and Research Centers contribute scientific expertise. They engage schools in research projects and offer training programs for teachers and students. Their involvement ensures that the Blue School initiatives are grounded in scientific knowledge. NGOs focus on marine conservation, pollution, climate change, and sustainable practices. They bring specialized knowledge and work on targeted projects that align with the Blue School's objectives, particularly fostering active citizenship. Projects often encompass collaborative efforts that bring together multiple stakeholders to address specific challenges. They can be pilot projects or large-scale funded initiatives to achieve goals within the network. Together, these partners create a robust support system for the Blue School network, ensuring that ed-

educational programs are comprehensive, scientifically accurate, and widely accessible. Their collaboration enhances the impact of the Blue School initiatives, fostering a well-rounded approach to ocean literacy and sustainability.

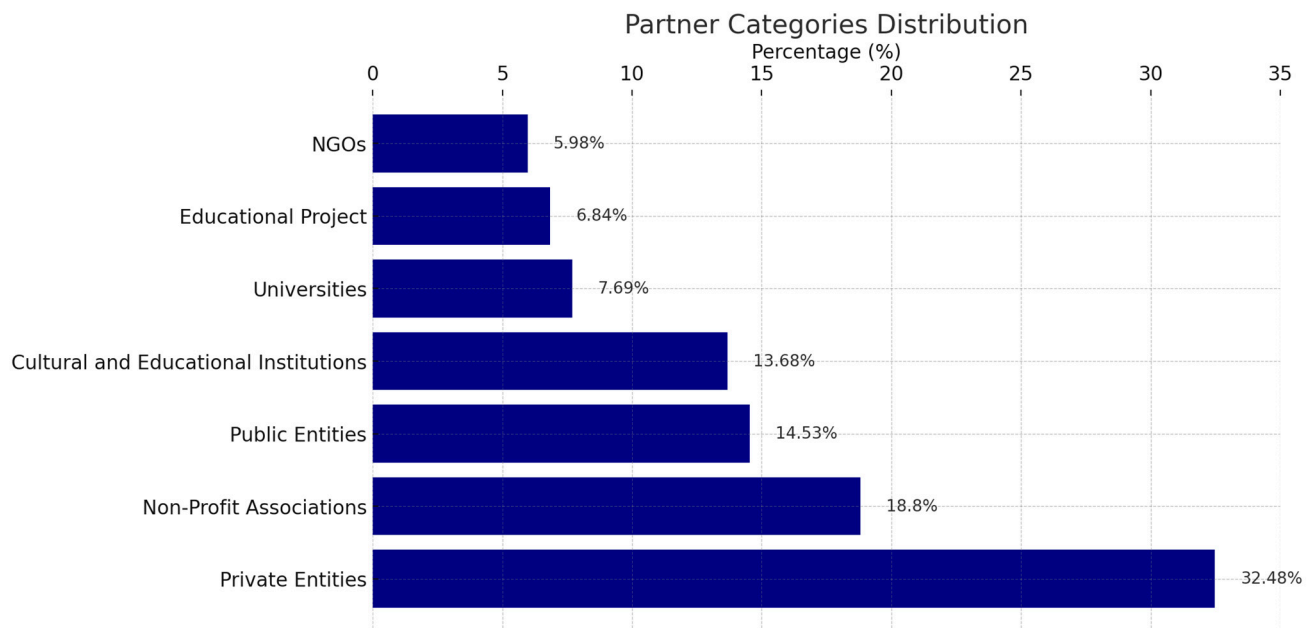


Figure 11. Partners of the Blue School Network, data from 2024.

6. Discussion

This analysis aims to deepen the understanding of ocean literacy in an educational context by examining the Blue School Program and its criteria, which support interdisciplinary, intercultural, and locally rooted educational practices. The findings suggest directions for future studies to explore the impact of BS programs in achieving meaningful learning outcomes in schools. It is intended as a resource for policymakers, educators, and researchers interested in developing or expanding Blue School networks internationally.

The findings of this study are shaped by the analytical framework applied, which emphasizes the ocean literacy framework. These criteria provided a consistent and replicable basis for evaluating how Blue School projects align with ocean literacy goals while also framing the scope of the interpretations presented. This analytical lens highlights the program's contributions and underlines the need for future studies to assess broader empirical impacts.

Nevertheless, while the program's approach aligns well with global educational objectives, certain limitations should be addressed to enhance its relevance and applicability. For instance, schools in under-resourced or inland areas face significant challenges in accessing resources and establishing meaningful partnerships with maritime stakeholders. Strategies to address these challenges include increasing funding and logistical support, providing adequate teacher training, and adapting curricula to more easily integrate ocean literacy initiatives, as noted by Fauville *et al.* [57]. Additionally, fostering connections with regional non-profit organizations or leveraging inland environmental topics could help mitigate these disparities, ensuring a more equitable implementation of ocean literacy programs [57–59].

This study seeks to contribute to academic discussions on ocean education and sustainability by situating the Blue School Program within educational domains. The findings provide a starting point for evaluating the program's effects on teachers and students and offer a practical framework that could inform the implementation of similar initiatives in

diverse cultural and geographical settings. When considering the transferability of the Blue School Program to other geographical and cultural contexts, it is essential to recognize the unique aspects of Portugal's implementation and the universal principles that make the program adaptable.

Portugal's extensive coastline and historical ties to the ocean have significantly shaped the program's design. However, the structured criteria outlined in Table 1 offer a flexible framework that can be tailored to align with other regions' specific environmental, cultural, and educational priorities.

For instance, while coastal areas may emphasize marine biodiversity and conservation, inland regions could adapt the program to focus on freshwater ecosystems or local sustainability issues.

Stakeholder engagement is critical for successful adaptation. The program can address region-specific challenges and opportunities by involving local educators, policymakers, and community members, fostering ownership and sustainability. These adaptations highlight the Blue School Program's potential to inspire similar initiatives globally while remaining sensitive to local contexts [28,31].

This analysis hopes to support the growth of international networks dedicated to advancing ocean literacy by broadening the understanding of how structured educational initiatives can promote ocean literacy.

A central feature of the Blue School Program is its structured approach to implementing ocean literacy principles through well-defined criteria. These criteria translate the program's objectives into tangible educational outcomes by connecting specific learning strategies with anticipated knowledge, skills, and attitudes competencies [13,19,48].

The framework outlined in Table 1 highlights the program's comprehensive approach by detailing how each criterion connects with specific strategies that promote active and engaged learning [60]. For example, Problem-Based Learning (PBL) encourages students to address real-world problems, fostering critical thinking and knowledge application [52]. At the same time, Inquiry-Based Learning (IBL) engages students in self-directed exploration and solution-seeking. These strategies are deeply embedded in the program's structure, making ocean literacy integral to students' educational experiences.

However, despite these strengths, effectively implementing these learning strategies requires significant support and resources. For instance, schools with limited access to professional development opportunities for teachers may struggle to fully integrate ocean literacy concepts into various subjects [58,61]. Without ongoing training and a clear understanding of interdisciplinary and active learning techniques, teachers may struggle to consistently implement strategies such as PBL and IBL. This dependency on teacher training and school resources highlights a potential limitation of the program, as its success in each school is influenced by the availability of sustained support.

Additionally, while the structured framework encourages partnerships and community involvement, these connections often depend on the local context. Schools situated further from coastal areas, for instance, may have limited access to maritime resources and regional stakeholders, which is crucial for real-world learning experiences in ocean literacy [26,58]. Although some inland schools overcome this barrier through creative approaches, such as partnerships with non-profit organizations or exploring inland environmental topics, the lack of direct access to coastal resources can create disparities in student engagement compared to coastal schools [57,62,63].

By situating ocean literacy within a whole-school approach that encourages collaboration among students, teachers, and community stakeholders, the Blue School Program also aligns closely with the objectives of the SDGs, particularly SDG 4 (Quality Education), SDG 14 (Life Below Water), and SDG 17 (Partnerships for the Goals). Koenigstein et al. [61],

United Nations [62], and Connecting to the Oceans [63] highlight how this alignment positions the program.

Despite effectively linking ocean literacy with sustainability goals, the program lacks formalized mechanisms to track long-term outcomes, such as behavioral changes, career inclinations, and lasting impacts on students and educators [58]. Bridging this gap is crucial to demonstrate the program’s tangible contributions to ocean literacy and sustainable practices.

Establishing a robust evaluation framework is essential to addressing these limitations and enhancing the program’s capacity to achieve its goals. Below, we propose a set of indicators designed to provide actionable insights and facilitate continuous improvement.

Table 2 outlines the proposed assessment metrics, detailing the dimensions to be evaluated and suggesting practical methods for data collection. These indicators include student engagement, stakeholder involvement, OL’s cognitive and behavioral dimensions, the quality and sustainability of implemented projects, and inclusivity across diverse demographics. They provide a replicable model to strengthen the Blue School Program’s evaluation processes and scalability. For example, the proposed ‘Equity and Inclusivity’ indicator directly addresses disparities in resource access, providing a mechanism to ensure more equitable implementation across diverse school contexts.

Table 2. Proposed Blue School Program assessment indicators.

Indicator	Description	How to Measure
Student Engagement	Measure the number of students participating in Blue School activities and their level of engagement.	Track participation rates, conduct engagement surveys, observe classroom participation, and monitor extracurricular involvement in ocean literacy clubs or outdoor projects.
Stakeholder Involvement	Assess the level of collaboration with partners in Blue School initiatives.	Conduct surveys and interviews with partners, track collaboration records, and measure participation rates in Blue School events.
Ocean literacy Dimensions	Track improvements in students’ and teachers’ knowledge, awareness, attitudes, and behaviors related to OL.	Administer pre- and post-tests to evaluate ocean literacy dimensions and conduct focus groups or interviews with students and teachers.
Quality and Sustainability of Projects	Monitor the quality, long-term impact, and continuity of Blue School projects within schools.	Conduct longitudinal studies to track impact over time, follow up on completed projects, and hold annual or semi-annual meetings to assess project quality and effect.
Equity and Inclusivity	Measure the program’s reach and effectiveness across demographic groups to ensure equal access for all students.	Analyze demographic data to identify participation trends, conduct inclusivity surveys, ensure equal access to resources, and measure participation across diverse student groups.

Finally, although the program employs diverse teaching strategies, such as collaborative learning and active participation, its sustainability heavily depends on the willingness and resources of partner organizations and schools. This reliance poses significant challenges in resource-limited settings, as neither stakeholders nor schools receive direct

funding to support these initiatives. Expanding financial support or establishing structured incentives for stakeholders could strengthen these partnerships and facilitate more consistent implementation across diverse school contexts [57,58].

However, while the Blue School Program offers promising contributions to ocean literacy through a scalable and adaptable framework, its overall effectiveness is shaped by multiple internal and external factors. These factors highlight the complexity of ensuring the program's success across various contexts:

1. **Coordination and support:** The program relies on sustained and active coordination. Schools may struggle to implement ocean literacy initiatives effectively and sustainably without structured guidance, such as consistent meetings and strong support [57].
2. **Resource and geographic constraints:** For inland schools or those far from marine environments, overcoming geographic barriers requires creative solutions, such as remote partnerships or adaptable content. However, disparities in resource availability can hinder the program's potential, leading to inconsistent experiences across regions [51,58].
3. **Community and stakeholder engagement:** Partnerships with community organizations enhance the program's reach, but their availability and quality may vary widely. Strengthening these networks through incentives or capacity-building measures could address these disparities and ensure the program's longevity in diverse settings [63].
4. **Equity and inclusion:** Ensuring equitable access to opportunities remains a persistent challenge, particularly in under-resourced or inland communities. Tailored interventions, such as targeted funding or specialized teacher training, are essential to bridge gaps and provide all students meaningful engagement [9,16].
5. **Evaluation and adaptability:** The program's long-term impact on students' knowledge and behaviors remains underexplored. Establishing clear evaluation indicators, such as those proposed in Table 2, could help monitor outcomes, guide future adaptations, and enhance the program's ability to meet evolving educational needs [62,64].

Our analysis identifies several key educational dimensions within the program, creating a structured framework that may guide other countries in implementing similar initiatives. This theoretical foundation lays the groundwork for future studies to examine the program's empirical dimensions and provide a fuller assessment of its impact on teachers and students. Furthermore, the Blue School Program promotes a holistic approach to ocean literacy, addressing cognitive, social, and civic dimensions [65]. This approach can give students the skills and knowledge to engage meaningfully with sustainability and ocean-related issues in their communities and beyond.

Additionally, the program's inclusion in the Global Blue School Network, as recognized in the Venice Declaration for ocean literacy in Action and the Ocean Decade Vision 2030 White Papers, underscores its role in supporting international efforts to enhance ocean literacy in the education setting. These documents briefly highlight the network's importance in fostering collaboration and scalability across diverse contexts [65,66].

7. Conclusions

This study provides an in-depth analysis of the Blue School Program, examining its structure, educational objectives, and potential to advance ocean literacy as a cornerstone of sustainability education. By integrating scientific, cultural, social, and ethical dimensions, the program offers a comprehensive framework that addresses the growing need for educational models promoting student development and sustainable practices from an early age.

The program's conceptual framework fosters ocean literacy and sustainable behaviors across diverse educational settings, emphasizing cognitive, social, and civic dimensions. However, its success relies heavily on effective coordination, robust partnerships, and adaptable support mechanisms tailored to each school's unique geographic and socioeconomic contexts.

To address these challenges and enhance the program's long-term impact, this study proposes a set of evaluation indicators outlined in Section 6. These metrics, which include monitoring student engagement, stakeholder collaboration, improvements in ocean literacy, and project sustainability, provide a replicable model to strengthen evaluation processes and support the program's scalability.

While the program offers a promising global framework for advancing ocean literacy education, achieving equity in its implementation remains a significant challenge. Tailored strategies and additional resources are essential to ensure inland and under-resourced schools have equal access to the program's benefits. Addressing these disparities is critical for enhancing the program's effectiveness and inclusivity.

The Blue School Program closely aligns with the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), SDG 14 (Life Below Water), and SDG 17 (Partnerships for the Goals). Its inclusion in the Global Blue School Network underscores its potential as a model for international collaboration in ocean literacy and sustainability education.

However, while the structured framework provides a valuable and consistent approach to evaluating the program, it also frames the interpretative scope of the results. Future studies should empirically assess additional dimensions of the program's impact, including its effects on student behavior and community engagement. Such evaluations will be instrumental in refining the program's adaptability and scalability, establishing it as a robust model for integrating ocean literacy into global educational frameworks and advancing sustainability and responsible citizenship on a broader scale.

8. Limitations of the Approach

This is a conceptual analysis of the Blue School Program, focusing on its framework, educational objectives, and potential to foster OL within a sustainability education context. Several limitations must be acknowledged. This analysis is primarily theoretical and does not include empirical data directly assessing the program's impact on teachers, students, or community partners. Therefore, conclusions regarding the program's effectiveness are based on analyzing its structure and intended outcomes rather than on observed impacts.

Future research will include three additional studies that assess the Blue School Program's impact on different participant groups: teachers, students, and community partners. These studies will employ empirical methods, including surveys and interviews, to understand how involvement in the Blue School Program influences participants' attitudes, knowledge, and behaviors. This approach will ultimately provide a comprehensive evaluation of the program's strengths, areas for improvement, and long-term effectiveness, helping to adapt the model for effectively advancing ocean literacy.

Author Contributions: Conceptualization, R.L.C. and C.F.; methodology, R.L.C.; validation, R.L.C., C.F.; formal analysis, R.L.C.; investigation, R.L.C.; resources, R.L.C.; data curation, C.F.; writing—original draft preparation, R.L.C.; writing—review and editing, R.L.C., C.F.; visualization, R.L.C.; supervision, C.F.; funding acquisition, C.F. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by National Funds through FCT-Portuguese Foundation for Science and Technology, I.P., under the scope of UIDEF—Unidade de Investigação e Desenvolvimento em Educação e Formação, UIDB/04107/2020, <https://doi.org/10.54499/UIDB/04107/2020> and through a PhD grant, number 2023.00678.BD, granted to Raquel Costa.

Informed Consent Statement: Written informed consent has been obtained from the participants to publish this paper.

Data Availability Statement: The data underlying this study are proprietary to the Blue School Program and are not publicly accessible in their raw form to ensure the privacy of the involved institutions and individuals. Access may be granted for valid academic or research purposes through a formal request to the Blue School Program administration.

Acknowledgments: We thank all the teachers, students, and school administrators who participated in the Blue School Program and contributed valuable feedback and insights. Special thanks to my program team for their unwavering support and guidance, which were crucial for the successful implementation and sustainability of the program. We also thank the local communities, partner organizations, companies, non-profit associations, and public entities, particularly the scientific committee, for their collaboration and support. Their involvement and commitment enhanced the Blue School Program's reach and impact.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the study's design, data collection, analysis, or interpretation, manuscript writing, or decision to publish the results.

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