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Teresa J. Kennedy *Editor*

Ocean Literacy: The Foundation for the Success of the Ocean Decade, Volume III

Accelerating Communication, Technology, and Global Initiatives

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Editor

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BlueMinds4Teachers: The Chronicle of an EU4Ocean Project Fostering Ocean Literacy in Education for Sustainable Development

Panayota Koulouri, Athanasios Mogias, Francesca Alvisi, Maria Cheimonopoulou, Melita Mokos, Evelyn Paredes Coral, and Silja Teege

Abstract

Education directed towards sustainability comes in response to the challenges of our increasingly interconnected planet while its future is at stake. Ocean Literacy (OL), via behavioral change initiatives and a systems approach, aims at connecting Ocean Science and Education for Sustainable Development (ESD). The objective of the BlueMinds4Teachers project was to strengthen the skills of teachers and other educators in OL issues through the collaboration of marine and freshwater scientists, experts from education and social sciences, teachers experienced in implementing blue projects, and young Ocean ambassadors. The objectives were: (a) to bring the inter- and multi-disciplinary approach of Ocean science issues to teachers and other educators enabling them to improve their knowledge on OL issues and integrate them into ESD; (b) to bridge skills and knowledge gaps by integrating science and pedagogy, improve social learning and critical thinking; (c) to design, develop, implement, and assess an interactive online training course to improve skills of teachers and other educators in promoting OL at schools and educa-

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tional communities; (d) to give the opportunity to meet, learn, discuss, and debate on rules and strategies of marine and maritime research, testing of already available teaching plans and modules, evaluation of possible additions, modifications, weaknesses, and strengths.

Keywords

Ocean Literacy (OL) · Teachers · Marine educators · Blue careers · Lesson plans · Pedagogical strategies

8.1 Introduction

Ocean Literacy (OL) is recognized as a baseline for Ocean conservation and sustainable management of freshwater and marine resources. The United Nations (UN) consider OL one of the crucial steps towards a sustainable future of the Ocean, and critical for the success of the UN Decade of Ocean Science for Sustainable Development (UNESCO-IOC 2021). Ocean Literacy is relevant for all of the Ocean Decade Challenges, which is specifically emphasized in "Challenge 9: Ensure comprehensive capacity development and equitable access to data, information, knowledge and technology across all aspects of Ocean science and for all stakeholders", and "Challenge 10: Ensure that the multiple values and services of the Ocean for human well-being, culture and sustainable development are widely understood, and identify and overcome barriers to behavior change required for a step change in humanity's relationship with the Ocean" (UNESCO-IOC 2021).

Enhancing OL in formal education is the priority of the Ocean Decade (IOC-UNESCO 2022). Therefore, training of formal educators (including in-service and pre-service teachers), and non-formal educators (e.g., those working in aquaria and museums), together with the development of resources, is encouraged by the Ocean Decade (UNESCO-IOC 2021). In addition, education is identified as one of the key drivers for restoring society's relationship with the Ocean (Glithero et al. 2024).

The interdisciplinary and transdisciplinary approach that connects freshwater, marine, education, and social scientists is an acknowledged way of communicating complex Ocean issues. Moreover, the UNESCO-IOC (2024) recommends a transdisciplinary approach to education fostering an Ocean-literate workforce.

This chapter showcases an example of successful education practice, outlining the activities and outcomes of the BlueMinds4Teachers project, including the development of an online teachers' training course and a digital toolkit. The results of surveys carried out during and after the course in order to evaluate its short-term impact and overall performance are also presented. The project itself has been driven by scientists and educators whose work is associated with marine, freshwater, education, and social science. It was developed to provide opportunities and resources for formal and non-formal educators, consequently enhancing OL in the education community. In addition, it connected OL and the Blue Economy, emphasizing the role of the former in raising awareness in education on Blue Economy to attract youth to engage in Ocean-related careers, i.e. Blue Careers (European Commission 2021).

8.1.1 The Concept of OL in Education for Sustainable Development

The Ocean Decade focuses on generating knowledge and data to support sustainable development. However, its White Paper for Challenge 10, referring to "Restoring Society's Relationship with the Ocean", emphasizes the major societal transformations needed to create a sustainable

and equitable future (Glithero et al. 2024). More specifically, behavior changes in personal, emotional, and cultural connections with the Ocean are necessary beyond conventional scientific methods and proper science communication. Education for Sustainable Development (ESD), climate education, and global citizenship are becoming not only essential areas of pedagogical focus but also powerful instruments of social change. The concept of OL aims to connect Ocean science and ESD through behavioral change initiatives and adaptation of systems approach. Whereas education is an important driver, OL is an outcome, in a society that understands and values the Ocean's vital role in our lives and behaves in ways that ensure its health. Therefore, the concept of OL is central to operationalizing Challenge 10 and the United Nations Ocean Decade legacy.

Ocean Literacy is fundamental to many of the UN Sustainable Development Goals (SDGs), particularly to SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, SDG 6: Ensure availability and sustainable management of water and sanitation for all, SDG 13: Take urgent action to combat climate change and its impacts, and SDG 14: Conserve and sustainably use the Oceans, seas and marine resources for sustainable development (Mokos et al. 2019). Education for Sustainable Development, including Climate Literacy and OL, needs to be embedded in education as a cross-cutting issue across all educational levels.

Teachers' training and their professional development must be aligned with the aforementioned critical topics, ensuring that educators have access to free, high-quality, and up-to-date resources. BlueMinds4Teachers project is very relevant in the general context of ESD and, therefore, towards SDGs and Challenges of the United Nations Ocean Decade.

8.1.1.1 The Pedagogical Approach and the Social Aspects

Participatory methods in teaching and learning processes are the best for the educational objectives to be properly met and communicated to students, youth, and learners (e.g., Ballantine and McCourt 2007; Jacobs et al. 2016). These methods depend upon the active involvement of learners in educational activities. They have drawn their theoretical and methodological elements mainly from critical pedagogy and socio-cultural theories of learning. In addition, they focus not only on the outcome of the teaching procedure but also on the learning process; this way, learners are deeply and authentically involved in the educational process, starting from their own experiences (constructivist approach), influencing, shaping, and building learning in interaction with other learners and the local community.

Participatory teaching and learning methods cultivate socio-political skills and pedagogical values through an interdisciplinary and systemic approach of knowledge, hands-on science, project-based and inquiry-based learning, critical thinking, and democratic ethos. Therefore, they enable learners to improve their relationship with the Ocean, acquire the necessary competencies to participate in decision-making processes and play an active role in a modern democratic society.

8.1.1.2 Empowering the Connection Between Freshwater and Marine Ecosystems

Linking school learning and other educational activities to the real-life daily experiences of students and learners, regardless of where they live (coastal or inland), is a key element in their understanding that the Ocean influences and is influenced by freshwater and terrestrial environments (a conceptual OL principle). Freshwater, coastal, and marine ecosystems are inextricably linked (Lamberti et al. 2010). Streams and rivers

transport water, sediments, organic matter, and nutrients downstream to estuaries and coastal ecosystems, thus influencing their productivity. The maintenance of land elevation in deltas and coastal areas and the interception of coastal erosion are also important, especially under the prism of climate change. Nutrient transfers can occur in both directions, as nutrients return from the Ocean to freshwater and terrestrial environments through biogeochemical cycles (e.g., the life cycle of birds and anadromous fishes enriching food webs).

Several pressures that can affect the coastal and marine environments come from anthropogenic activities on land, i.e. agriculture, industrial activities, wastewater treatment, forestry, and hydroelectric energy production (European Environmental Agency 2024). Understanding the interconnection between freshwater and marine ecosystems is a prerequisite for a holistic and integrated approach to managing all water bodies, promoting sustainability in all aspects of the water cycle. To this end, educational projects empowering the connection between freshwater and marine ecosystems are important as only a few have been implemented in Europe, at least, according to the Network of European Blue Schools.

8.1.2 The Background of the Project

In 2023, "BlueMinds4Teachers: Fostering Ocean Literacy in Education for Sustainable Development" was selected as one of the three winning projects of the "Blue Challenge" proposed by the European Ocean Coalition (EU4Ocean), inspired by the European Union (EU) Year of Skills, to drive collective action on OL. The EU4Ocean, a bottom-up inclusive initiative promoting OL in the EU consists of three components: (i) the EU4Ocean Platform, which includes organizations and initiatives that collaborate and mobilize OL efforts on priority issues such as Climate and Ocean, Food from the Ocean, and Healthy and Clean Ocean; (ii) the Youth4Ocean Forum, a free platform for young people engaged in the protection of the Ocean and its sustainable management; (iii) the Network of European Blue Schools, which includes schools implementing educational projects addressing Ocean issues.

The one-year project BlueMinds4Teachers (October 2023–September 2024) aimed at strengthening the skills of educators in OL issues through the collaboration of (a) marine and freshwater scientists, (b) experts from education and social sciences, (c) teachers experienced in the development and implementation of blue projects at schools, and (d) young Ocean ambassadors (e.g., university students, early career Ocean professionals). Jointly interactive meetings and activities were planned to provide educators with the motivation, capability, and opportunity to increase their awareness on Ocean issues and integrate them into their educational initiatives. Synergies with other projects such as Offshore Renewable Energies partnership in the Pact of Skills—FLORES, BlueGeneration, Next BlueGeneration were also essential for the successful implementation of the project in order to update educators regarding OL initiatives in Europe related to Blue Economy and Blue Careers.

The rich experience and previous knowledge of all the involved institutions (i.e. National Research Council, Italy; Hellenic Centre for Marine Research, Greece; Democritus University of Thrace, Greece; University of Zadar, Croatia; the Hydrobiological Station of Pella, Greece), such as participation in the BlueSchoolsMed and BlueNIGHTS projects, the Mediterranean region Working Group of European Marine Science Educators Association and publishing research on OL (e.g., Cheimonopoulou et al. 2022; Koulouri et al. 2022; Mogias et al. 2015, 2019, 2021, 2022; Mokos et al. 2019), were shared to work in an interdisciplinary way. The exchange of good practices among the project's partners, educators, and young people, along with the establishment of a constructive dialogue, was the basis for a dedicated workshop held in Croatia in January 2024. The participants collaborated to finalize the preparation of the course.

8.1.3 The Objectives of the Project

The objectives of the project were to (a) bring the inter- and multi-disciplinary approach of Ocean science issues to formal and non-formal educators (including university students), improve their ability to address and integrate them into the school curricula and other educational activities; (b) create a permanent working group where scientists, educators, and youth can interact effectively to build a robust educational community and innovative educational materials and tools; (c) contribute to bridging skills and knowledge gaps in educators, by introducing pedagogical methods and scientific knowledge, empowering social learning and critical thinking); (d) design an interactive online training course that can be reproducible, exportable, scaled-up and adaptable to local and national needs in EU countries and beyond.

The BlueMinds4Teachers project allowed elementary and secondary education EU (and non-EU) teachers and educators in non-formal education settings (e.g., aquaria, museums, zoos, science centers) to develop their skills in OL issues and increase their confidence in teaching about the Ocean and its resources. The aim was to support international best practices for Ocean education by integrating them into broader climate and sustainability education through teachers' training as well as educator and professional development certification programs.

8.2 The BlueMinds4Teachers Online Course

8.2.1 Co-Design and Co-Development of the Course

There is a global need for training of teachers and other educators in OL and the availability of educational resources. To contribute to this need, the BlueMinds4Teachers working group co-designed and co-developed a free-access online training course, advocating the protection of the Ocean and sustainable management of its resources. As already mentioned, a two-day hybrid workshop was organized at the University of Zadar in Croatia. Open discussions during the workshop concerned the content of an online course, the choice of interactive elements, the evaluation of the course's impact, and the communication and dissemination strategies of the project at the EU level. Furthermore, the teachers specifically requested that the outcome of the project, the best practices, and the lesson plans for each OL principle should be included in a digital toolkit.

During the discussions, it was kept in mind that teachers of elementary education usually have adequate Pedagogical Content Knowledge (PCK) and are therefore aware of teaching and learning strategies but lack sufficient Content Knowledge (CK) on Ocean science issues. On the other hand, secondary school teachers and other educators, especially natural scientists, may have sufficient CK on relevant topics but lack PCK. Regarding the social perspective addressed in the course, all educators have an opportunity to integrate Blue Economy key concepts and Blue Careers into their classrooms and other educational activities.

Central to the course was to highlight the connection of the OL framework to EU priorities and Missions (e.g., EU Mission: Restore our Ocean and Waters), SDGs, Ocean Decade, school curricula, and the Network of the European Blue Schools. This was achieved by providing content knowledge on Ocean science issues along with pedagogical strategies useful for implementing blue projects (e.g., hands-on activities, project-based and inquiry-based learning, open schooling) enhancing social learning, critical thinking, and scientific approach. These outcomes and processes are also the gateway to the Network of the European Blue Schools, which educates students and makes them aware of, and passionate about, sustainable Ocean management.

Overall, the content of the course was organized into four sections: (a) introduction to the project and connection to the Ocean Decade, EU Missions, and SDGs; (b) OL principles and their implementation in everyday life and teaching; (c) introduction to Blue Economy and Blue Careers; (4) pedagogical approach to teaching OL. As a

followup, the course was communicated and disseminated through social media channels.

8.2.2 Implementation of the Course

The online course was delivered in three sessions during April 2024 offering the opportunity to educators, university students, and researchers to meet, learn, discuss, and debate on (a) OL framework and Ocean issues; (b) EU priorities concerning the protection and sustainable use of the Ocean; (c) scientific methods, rules and strategies of marine and maritime research; (d) modern participatory teaching and learning methodologies.

The first session of the online course was held on April ninth, 2024, reaching almost 90 participants. This session started with an introduction to the project and its objectives, background of marine and aquatic education, the OL framework and its evolution to a multi-perspective concept, links to Agenda 2030 SDGs, the Ocean Decade Challenges, the EU Missions and priorities for 2019–2024, the Network of the European Blue Schools and inspiring blue projects. This was followed by the presentations of the first five OL essential principles, their related fundamental concepts and links to the above issues and school curricula. The second session on April 16th was attended by almost 75 participants. This session included the presentation of the last two OL principles and related fundamental concepts, the Blue Economy key concepts, a case study on offshore renewables, and video testimonials of people with blue professions from FLORES, BlueGeneration and Next BlueGeneration projects. On April 23rd, the third session reached about 70 participants and modern participatory pedagogical strategies that can be implemented for OL activities were presented.

In total, 184 teachers and educators registered for the online course from 28 EU and non-EU countries (Fig. 8.1). Around 40% of the total registered people were elementary school teachers, 30% were secondary school teachers, and 30% were other educators.

All sessions were held during the afternoon hours to allow teachers and other educators to attend outside their working hours and were recorded after their consent had been given for further use. During all sessions, an interactive approach was encouraged by inviting participants to write their questions and/or comments in the chat, and these questions were discussed at the end of the sessions. By the end of the course, all relevant materials were shared with the participants (e.g., presentations, references, and guidelines for developing a lesson plan) and certificates of attendance were issued.

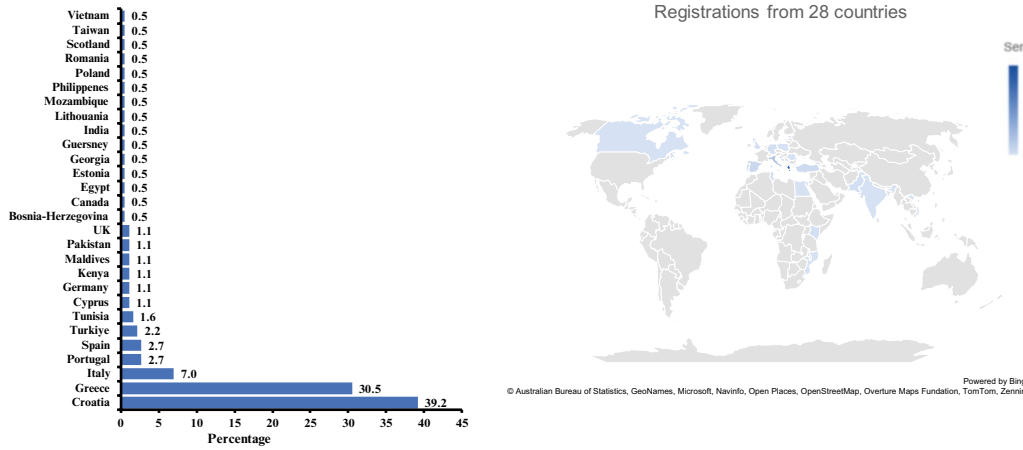

Fig. 8.1 Percentages of people registered for the BlueMinds4Teachers online course per country (map chart provided by Bing, color gradient is proportional to the number of registrations)

8.2.3 Mapping Participants' OL Knowledge and Attitudes—Surveys and Polls

Three surveys were performed during the entire course based on partners' previous experience, to get an insight into educators' understanding and connection to OL (Cheimonopoulou et al. 2022; Koulouri et al. 2022; Mogias et al. 2015, 2019; Mokos et al. 2019). The first one investigated their OL knowledge before and after the presentation of the OL principles, the second one focused on their knowledge and attitudes toward key concepts of the Blue Economy, and the last one inquired overall performance of the online course. In addition, to actively engage the participants during the course, a poll regarding the connection of a certain OL principle to curriculum topics was completed at the end of each OL principle presentation. All surveys and polls were delivered in Google Forms.

8.2.3.1 Survey 1: OL Knowledge

This survey was prepared to measure the short-term impact of the BlueMinds4Teachers course by assessing the participants' content knowledge regarding Ocean science issues before and after the online course. This pre- and post-survey included 18 questions concerning the 7 OL principles and the 45 fundamental concepts presented during the course along with some demographic information. Just before the beginning of the OL principles presentation, 76 attendees completed the online survey, of which approximately 92% were females, mainly from Croatia and Greece. Environmental education programs had been designed and implemented by approximately 67% of respondents, while marine education programs were carried out by 40% of them. Different age groups of participants were well represented, most holding a master's degree (Figs. 8.2a, b). Half of them were working in elementary schools, while both new professionals (1–5 years of service) and experienced ones (>20 years of service) were the majority (Figs. 8.2c, d). Apart from respondents with degrees in science (including marine science) and pedagogics, there were several other disciplines engaged (e.g., language, management of

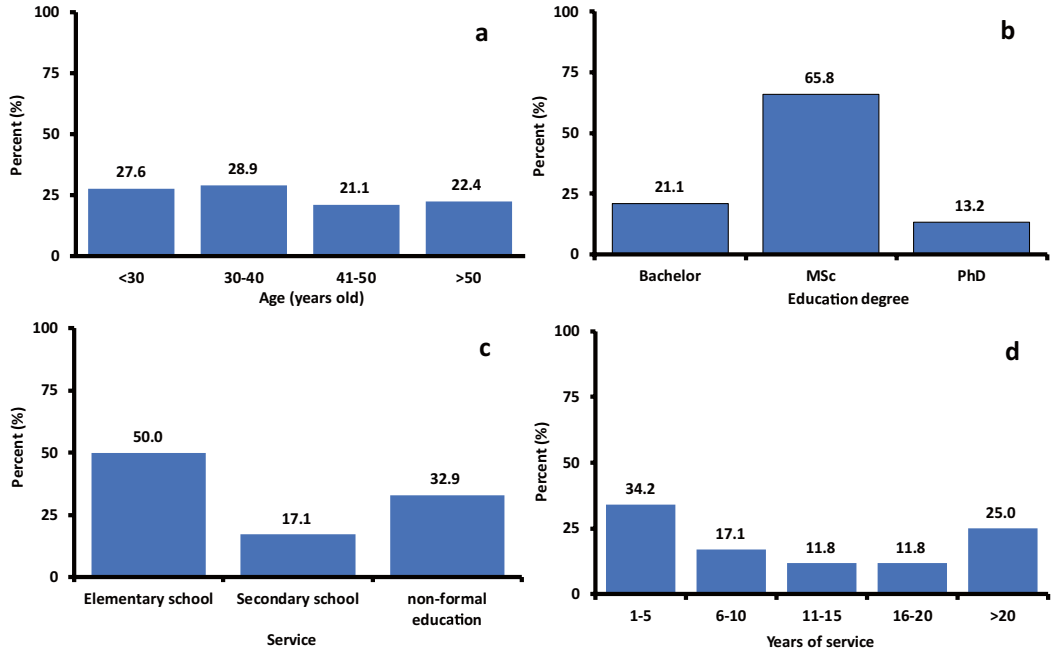

Fig. 8.2 a–d Demographics of the attendees participating in the OL content knowledge pre-test of the first survey

natural ecosystems, early childhood education, Information and Communication Technology).

After the presentation of OL principles, 47 attendees filled in the online survey, of which 98% were females. Environmental Education programs had been designed and implemented by approximately 77% of the respondents, while marine education programs were carried out by approximately 49%. Many respondents were over 50 years old, and most of them had a master's degree (Figs. 8.3a, b). Almost half of them were working in elementary schools, while relatively new professionals (1–5 years of service) and experienced ones (>20 years of service) were the majority (Figs. 8.3c, d). Most of the respondents had a degree already portrayed in the previously mentioned disciplines.

The survey results showed that the respondents possessed a relatively moderate to high level of knowledge on Ocean science issues. However, the online course further increased their content knowledge about OL principles and concepts. More specifically, concepts of Principle 3 "The Ocean is a major influence on weather and climate" and Principle 4 "The Ocean makes Earth habitable" were further clarified as well as Principle 2 "The Ocean and life in the Ocean shape the features of Earth" (Table 8.1). Nevertheless, further work is needed to evaluate the conceptual understanding of the general Ocean sciences content, focusing on the knowledge component and other OL dimensions (Mogias et al. 2015; Paredes Coral et al. 2022).

8.2.3.2 Survey 2: Knowledge and Attitudes Towards the Key Concepts in Blue Economy and Blue Careers

The next online survey was conducted after the end of the second session. Questions covered topics related to knowledge and attitudes toward the key concepts of the Blue Economy and Blue Careers. Of the approximately 75 attendees, 29 completed the survey, of which most were females (92.9%). Almost half of the respondents were over 50 years old with a master's degree (Figs. 8.4a, b), while most had been working as teachers/educators either for a few years (1–5) or for more than 20 years (Fig. 8.4d). Respondents from all teaching levels of service were well rep-

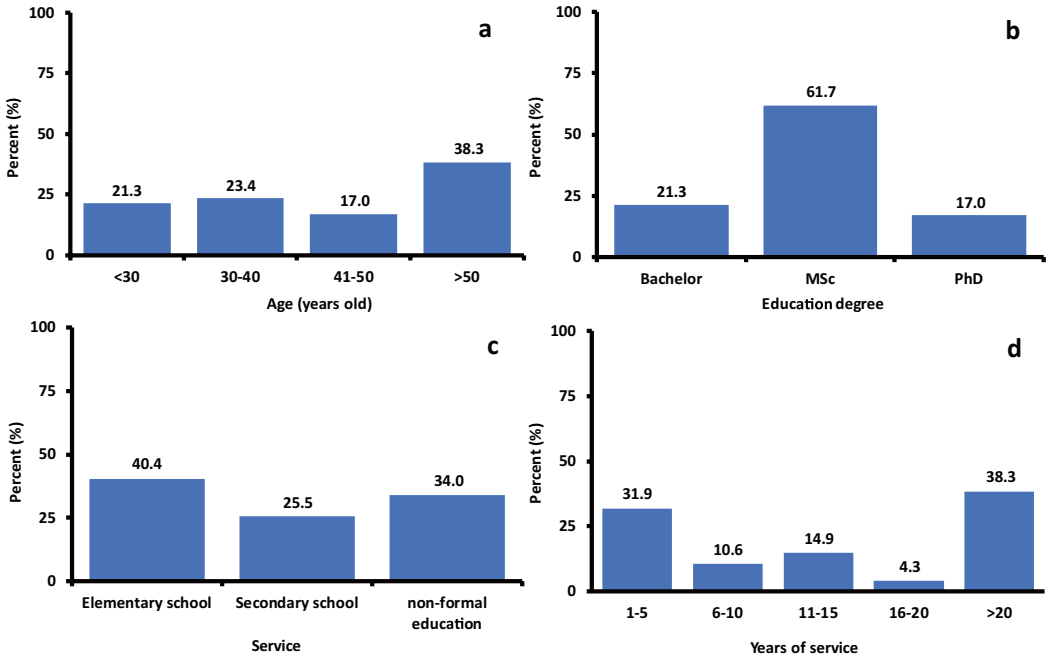

Fig. 8.3 a–d Demographics of the attendees participating in the OL content knowledge post-test of the first survey

Table 8.1 Short-term impact evaluation of the BlueMinds4Teachers online course on the participants regarding content knowledge on Ocean science topics; percentage (%) of correct answers received before (Pre-test) and after (Post-test) attending presentations related to OL principles and concepts (correct answers are indicated in bold)

Survey Statements		% correct answers		
		Pre-test	Post-test	p-level
1.1	The Mediterranean Sea is connected to **all the parts of the Ocean (OL-1)**	69.7	72.3	*Ns*
1.2	Most of the water on the Earth is **in the Ocean (OL-1)**	88.2	97.9	*Ns*
1.3	The form of the coastline is modified mainly by **seawater motions (OL-2)**	75.0	76.6	*Ns*
1.4	If you walk in the mountains and see a rock containing fish fossils, it means that **the rock with the fish fossils was formed a long time ago in a sea or lake (OL-2)**	82.9	95.7	*
1.5	The first living organisms on Earth lived **in the Ocean (OL-2)**	84.2	97.9	*
1.6	Most of the rainwater falling on land originally came from **the tropical Ocean (OL-3)**	35.5	53.2	*Ns*
1.7	Scientists think that climate change will cause **sea level rise (OL-3)**	93.4	95.7	*Ns*
1.8	The climate of a coastal area would experience **hotter summers and colder winters** if there was no sea **(OL-3)**	60.5	74.5	*Ns*
1.9	**Marine photosynthetic organisms** are the main source of the oxygen that living beings breathe **(OL-4)**	75.0	89.4	*Ns*
1.10	The marine environment is home to different animals **depending on the sea depth (OL-5)**	82.9	93.6	*Ns*
1.11	The deep Ocean that is always in the dark has **many different species of organisms (OL-5)**	75.0	78.7	*Ns*
1.12	The Ocean is home to **organisms of many different species (OL-5)**	98.7	95.7	*Ns*
1.13	Most of the world's goods are transported **by ships (OL-6)**	98.7	95.7	*Ns*
1.14	The Ocean influences the life of people **living everywhere around the world (OL-6)**	94.7	95.7	*Ns*
1.15	What I throw in the sink influences **freshwater and marine organisms as well as humans (OL-6)**	84.2	93.6	*Ns*
1.16	**Fish** is the resource that is most at risk of being exhausted in the Ocean **(OL-6)**	73.7	80.9	*Ns*
1.17	**The deep Ocean** is the least explored environment **(OL-7)**	90.8	95.7	*Ns*
1.18	We need to study the Ocean so that **we will be able to sustainably use its resources (OL-7)**	86.8	89.4	*Ns*

Ns: Non-significant
*: Significant in ≤0.05 p level

resented (Fig. 8.4c). The correct responses refer to the most relevant factors for the formation of an Ocean-literate person in Blue Economy, namely knowledge, attitudes, behaviors, and self-interest (Table 8.2). The three requirements for a sustainable Blue Economy, namely social equity, environmental sustainability, and economic viability were also given as answers. The perceptions of the attendees concerning OL initiatives and skills that support and empower Blue Economy sectors and Blue Careers were very positive (Table 8.3). These results suggest that promoting cross-institutional and interdisciplinary cooperation among research institutions, marine education networks, and Blue Economy sectors is crucial to sustaining this international movement of OL and represents an urgent challenge (Paredes Coral et al. 2021).

8.2.3.3 Survey 3: The Online Course Performance

A final survey was prepared to assess the overall performance of the course and to help BlueMinds4Teachers consortium improve the online course and its content. This survey was administered after the end of the third session. Of the approximately 70 attendees, 42 responded to the survey, of which most were females (92.9%). Almost 80% of the respondents had implemented Environmental Education programs, while 60% carried out marine education programs. More than half of them worked at the elementary

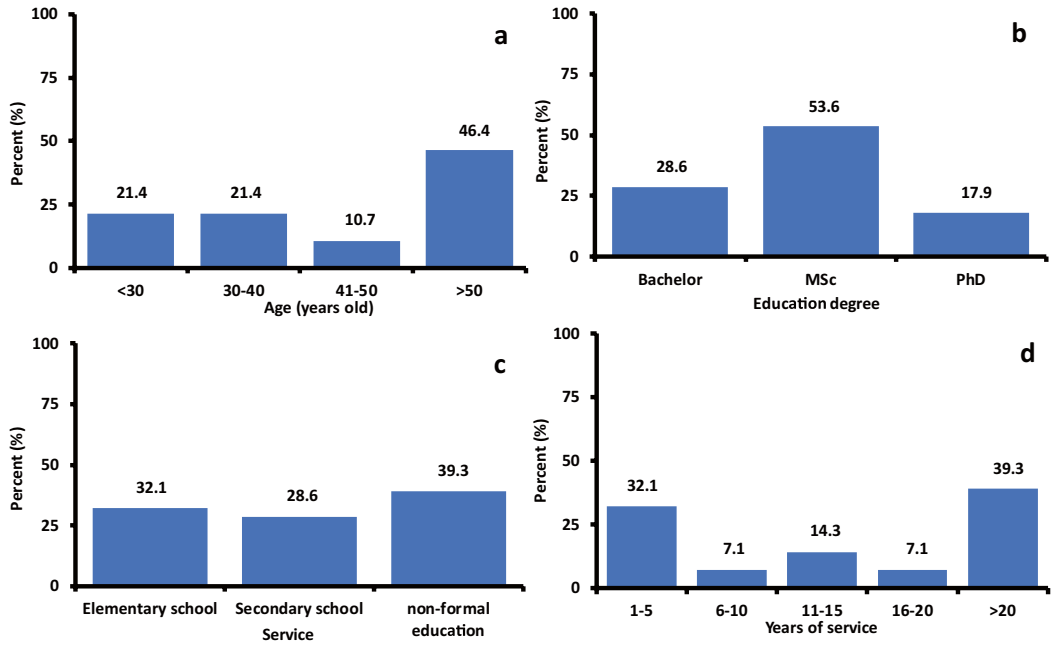

Fig. 8.4 a–d Demographics of the attendees participating in the second survey regarding the Blue Economy key concepts and Blue Careers

Table 8.2 Percentage (%) of correct answers received after attending presentations related to Blue Economy key concepts (correct answers are indicated in bold)

	Issues regarding an Ocean-literate person in the Blue Economy	% correct answers
2.1	The 3 requirements for a Sustainable Blue Economy are **(i) socially equitable, (ii) environmentally sustainable, and (iii) economically viable**	53.6
2.2	**Wave energy** is an emergent sector in the European Blue Economy	39.3
2.3	Social sciences can contribute to a more Sustainable Blue Economy **by understanding the way maritime workers connect with the Ocean**	32.1
2.4	According to the latest research, the most relevant factors to shape an Ocean-literate person in the Blue Economy is **(i) knowledge, (ii) attitudes, (iii) behaviors, and (iv) personal interest**	64.3

Table 8.3 Perceptions relevant to forming an Ocean-literate person in Blue Economy and Blue Careers (3.1–3.4), and evaluation of the session (3.5); Likert scale statements, with values ranging from 1 (totally disagree) to 5 (totally agree) (SD: standard deviation) received after attending the second session

	Attitude statements	mean	SD
3.1	Ocean Literacy can support the blue economy by empowering maritime workers to make informed and responsible decisions	4.29	1.243
3.2	Blue careers can become more attractive thanks to Ocean Literacy initiatives	4.36	1.254
3.3	Ocean Literacy skills are needed to achieve a more Sustainable Blue Economy	4.29	1.243
3.4	Ocean Literacy skills are transferable across sectors	4.11	1.197
	Evaluation of the second session	Mean	SD
3.5	In what degree did the course module meet the proposed objectives?	4.46	0.637

school while they were between 30 and 40 or more than 50 years old with a master's degree (Figs. 8.5a, b, c). Most of them had been working as teachers/educators for a few years or more than 20 years (Fig. 8.5d). In addition, more than 60% of the respondents were either specialist teachers or non-formal educators, i.e. teaching a particular subject such as biology, mathematics, physics, chemistry, geology, geography, Information and Communication Technology (ICT), but also language, history, foreign languages, arts, music, sports.

According to the results of this survey (Table 8.4), all different approaches, i.e. the teaching and learning methods, the OL framework, the Blue Economy, and the Blue Careers concepts seem equally necessary for the respondents to develop blue projects in their classroom and other educational activities. They also stated that they increased their knowledge about the topics covered in all three sessions. Furthermore, they declared that they can design and implement Ocean-related projects in their classrooms or non-formal education settings using modern participatory methods, applying inter- and/or multi-disciplinary approaches while collaborating with experts, stakeholders, and the local community. Overall, participants stated that they feel more confident about developing a blue project.

8.2.4 Polls: Connecting OL Principles to School Curricula

Further to the above-administered surveys, polls were also communicated to the participants asking them to propose topics, in the form of keywords, they considered relevant to the curricula they work on and to the OL principles and concepts. In total, 138 different topics were given for the 7 OL principles (Fig. 8.6). Most of the topics related to OL Principle 1 (33 topics in total) were relevant to common curriculum themes such as the water cycle, water properties, plate tectonics, sea level change, and climate change (Fig. 8.6a). The most popular keywords for OL Principle 2 (24 topics) were: biogeochemical cycles, plate tectonics, water cycle, rock cycle, elements circulation, and carbon cycle (Fig. 8.6b). For OL Principle 3 (25 topics), climate-related topics, i.e.

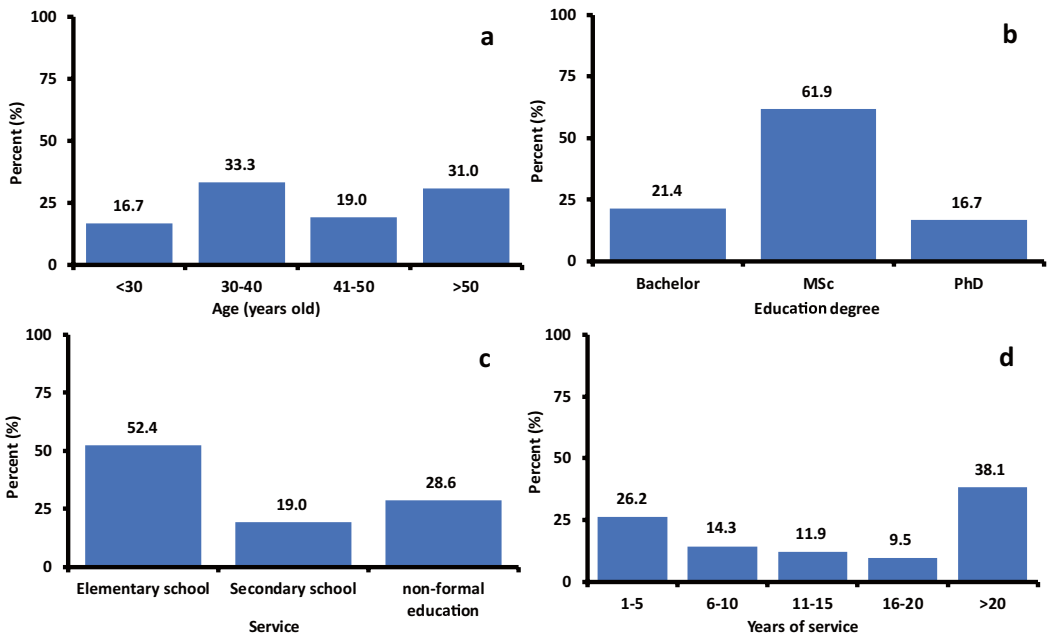

Fig. 8.5 a–d Demographics of the attendees participating in the third survey regarding the overall performance of the online course

Table 8.4 Likert scale statements (SD: standard deviation) with values ranging from 1 (totally disagree) to 5 (totally agree) of the performance survey

	To what extent did…	mean	SD
4.1	…The first session regarding Ocean Literacy Principles meet your educational needs?	3.95	0.795
4.2	…The second session regarding the social sciences approach (Blue Economy & Blue Careers) meets your educational needs?	3.88	0.968
4.3	…The third session regarding the pedagogical strategies that can be used in the classroom meet your educational needs?	4.21	0.813
4.4	…You increase your knowledge about sea-related issues?	3.98	0.950
4.5	…You increase your knowledge in order to integrate Blue Economy concepts into your classroom	4.05	0.825
4.6	...You increase your knowledge about the pedagogical strategies that can be used when designing and implementing an environmental education program?	4.12	0.861
4.7	…You develop responsible attitudes towards sea-related issues?	4.10	0.850
4.8	…You develop critical thinking towards sea-related issues?	4.14	0.814
	To what extent do you feel that…	Mean	SD
4.9	…this seminar convinced you to design and implement Ocean-related issues in your classroom?	4.05	0.825
4.10	…this seminar convinced you to use modern participatory methods when designing and implementing Ocean-related issues in your classroom?	4.29	0.742
4.11	…you can apply interdisciplinary and/or multidisciplinary approaches when designing and implementing Ocean-related issues in your classroom?	4.21	0.871
4.12	…you should collaborate with experts and/or stakeholders and/or the local community when designing and implementing Ocean-related issues in your classroom?	4.24	0.790
	Evaluation of the BlueMinds4Teachers course	Mean	SD
4.13	In what degree do you feel more self-confident about developing a blue project after this course?	4.24	0.821

Fig. 8.6 a–h Word clouds per OL principle revealing the topics the attendees consider relevant to the school curricula (a–g) and modern participatory teaching and learning methods that can be applied to implement blue projects (h)

climate change, carbon cycle, greenhouse effect, and water cycle, were the most frequent (Fig. 8.6c).

Photosynthesis, water cycle, and oxygen seem to be the most important topics (27 topics) for OL Principle 4 (Fig. 8.6d). For OL Principle 5 (19 topics), biodiversity, marine ecosystems, and food chains/webs were the most frequent answers (Fig. 8.6e). For OL Principle 6 (22 topics), alien species, human impact, overfishing, marine pol-

lution, coastal hazards, and marine biodiversity were the most popular keywords (Fig. 8.6f). The most popular answer for OL Principle 7 (19 topics) was sea exploration, while mapping, mathematical models, biodiversity monitoring, deep sea animals, and technology were also mentioned (Fig. 8.6g).

Several of the above-mentioned topics referred to more than three principles, such as photosynthesis, climate, Ocean acidification, water cycle, carbon, marine ecosystems, and marine resources, highlighting the interconnection among the OL principles. The most popular topics such as water cycle, water properties, biogeochemical cycles, plate tectonics, climate, climate change, photosynthesis, biodiversity, marine and Ocean ecosystems, food chains and webs, human impact, overfishing, marine pollution, sea exploration were expected to be recorded as relevant to OL principles and concepts as they are included into school curricula of different countries (Mokos et al. 2021). However, the total number of topics mentioned (138) was unexpectedly high, given that Ocean issues are generally missing from national curricula and school textbooks (Ezgeta-Balić and Balić 2024; Mogias et al. 2021, 2022).

Another poll was also administered during the third session so that participants could propose modern participatory teaching and learning strategies to develop and implement blue projects with their audiences in classrooms, aquaria, museums, and other education settings. Field study, debate, project method, case study, role-playing, brainstorming, and problem-solving, were mostly recorded (Fig. 8.6h).

8.2.5 The Digital Toolkit

Apart from the online course, one of the main outcomes of this project is a ready-to-use and open-access "digital toolkit". More specifically, it includes (a) the introduction to the BlueMinds4Teachers project; (b) audio-visual material from the webinars, one for each OL principle, illustrating fundamental concepts, relevant references, and links to the EU priorities and international initiatives; (c) audio-visual material from the webinars focusing on Blue Economy key concepts and Blue Careers, while proposing ways for educators to integrate them into their classrooms and other educational activities; (d) audio-visual material from the webinar focusing on the pedagogical strategies that can be applied for OL activities; (e) lesson plans proposed and developed by the project partners. Lesson plans were specifically requested by educators to help them develop new pedagogical paths in their classrooms and non-formal educational settings. They were produced based on OL content; therefore, seven lesson plans following each of the seven principles, containing examples of educational activities, were produced. All webinars were accompanied by PowerPoint presentations and references.

The BlueMinds4Teachers "digital toolkit" is accessible for free use through the European Marine Science Educators Association website under OL resources.

8.3 Conclusion

Based on the main tools used in this project, i.e. the online course, the surveys and polls, and the digital toolkit, lessons learnt and recommendations to ensure broad participation and engagement by teachers and other educators are: (1) course scheduling—for the sessions it is essential to choose the day and time of the week following their suggestions; (2) locally relevant examples—information provided must be linked to the real world and adaptable to different working and geographical environments to ensure their attention and understanding; (3) interactive elements—it is essential to create elements of interaction before, during, and after the course, to allow researchers to answer questions, to allow participants to make a constructive contribution to the course itself (active learners), and in general to keep their attention and motivation; (4) outputs—ready-to-use and open-access educational resources with basic guidelines (e.g., best-practices lesson plans) provided by marine and freshwater researchers as well as education and

social sciences experts are essential to promote further development and implementation of OL and to support the Network of European Blue Schools; (5) impact evaluation—it is fundamental to provide assessment tools to improve the quality of the proposed training courses and resources; (6) certification—accreditation certificate of participation is important for the role of teachers and other educators in supporting young learners toward Ocean issues and their professional development; and (7) sustainability—training modules should be implemented on a regular basis, while user-friendly materials should be translated in different languages.

Although there are many open-access resources related to OL issues, the OL framework is still largely unknown to teachers, marine educators, young people, and the general public. Therefore, in addition to Ocean science knowledge, and teaching and learning methods provided to teachers and other educators, there is a need for dissemination and communication of these topics. The concepts of the Blue Economy and Blue Careers should also be included.

The partners of the project disseminated and communicated its objectives, activities and outcomes by participating in several EU events during 2024 (e.g., European Ocean Days in Brussels, Ocean Decade Conference in Barcelona, European Science Education Research Association-ESERA mini-Conference in Valencia, European Marine Science Educators Association-EMSEA Conference in Zadar) to different communities (e.g., researchers, educators, other stakeholders, policymakers) in order to share information and encourage uptake of best practices. In addition, the community created by teachers, marine educators, early career Ocean professionals, other stakeholders and partners within the framework of the project will keep on updating news, events, new materials and tools, and projects through the social media channels and online contacts of the BlueMinds4Teachers team. This way future collaborations (e.g. BlueLightS), in-depth Ocean understanding and motivation of community action can be achieved as suggested by UNESCO-IOC (2021).

The BlueMinds4Teachers project, with more than 70 participants in each online session from many different EU and non-EU countries (e.g., Croatia, Greece, Italy, Portugal, Spain, Türkiye, Tunisia, Cyprus, Germany, Kenya, Maldives, UK), can be considered as a success story mostly due to bridging knowledge systems and practising interdisciplinary and transdisciplinary science as recommended for the Ocean Decade (UNESCO-IOC 2021). Natural and social scientists, educators, science communicators, policymakers—across generations, genders, and geographies—can collaborate on similar projects to increase the capacity and confidence of teachers and other educators (including scientists). This way the latter can develop impactful Ocean-related projects in classrooms, aquaria, museums, research centres, etc. Projects should also be adapted to locally relevant and national environments in culturally appropriate ways. Furthermore, sharing educational resources such as the digital toolkit co-developed within the framework of this project, is an excellent way of providing support to educators to develop the skills and resources necessary to include the Ocean across multiple platforms, languages, and places. This way, teachers and marine educators can raise levels of OL knowledge and emphasize the marine citizenship and identity of their young learners who, as future citizens and consumers, will inevitably influence the marine environment.

The promotion of a sustainable Blue Economy in education can also contribute to the development of the next generation of blue skills and provide opportunities for attractive, sustainable maritime careers supporting the European Green Deal initiatives (e.g., the Farm to Fork Strategy, the Sustainable Blue Economy Strategy, the EU Offshore Renewable Energy strategy, the Biodiversity Strategy and the Circular Economy Action Plan). Finally, Ocean and OL play a vital role in the entire UN sustainability agenda through education by setting specific learning objectives (cognitive, socio-emotional, and behavioral) for each different SDG in order to achieve "a sustainable, peaceful, prosperous and equitable life on earth for everyone now and in the future" (UNESCO 2017).

8.3.1 Summary

Key concepts explored in this chapter include:

- Training of formal and non-formal educators, along with the development of resources, in order to strengthen skills in OL issues is a priority of the Ocean Decade and one of the proper ways to achieve the UN sustainability agenda.
- Bridging knowledge systems and practising interdisciplinary and transdisciplinary science as recommended for the Ocean Decade is an acknowledged way of communicating complex Ocean issues not only to teachers and other educators but also to children, youth, policymakers and the general public.
- As the OL framework is still largely unknown to teachers, marine educators, young people, and the general public, there is a need for dissemination and communication of Ocean topics, including the concepts of the sustainable Blue Economy to attract youth and engage them in Ocean-related careers supporting the European Green Deal initiatives.

8.3.2 Recommended Resources

The following resources provide further insights and support on this topic:

- BLUENIGHTS. EU Researchers Night. A touch of Blue in the EU Researchers' Nights for a more Sustainable Use of the Ocean. (n.d.). BLUENIGHTS. https://www.ismar.cnr.it/web-content/bluenights/
- The Blue Education Platform. (n.d.). BlueLightS. https://blue-lights.eu/
- EMSEA. (n.d.). Ocean Literacy Resources. BlueMinds4Teachers Digital Toolkit. https://www.emseanet.eu/
- European Commission. (n.d.). Network of European Blue Schools. Maritime Forum. https://maritime-forum.ec.europa.eu/theme/Ocean-literacy-and-blue-skills/Ocean-literacy/network-european-blue-schools_en
- Forward Looking at the Offshore Renewables. (n.d.). FLORES. https://oreskills.eu/
- Island Liechtenstein Norway Grants. (n.d.). Blue Generation Project. https://www.blue-generation.org/index.php/en/
- Navigating Opportunities: Careers in the Blue Economy. (n.d.). Next BlueGeneration. https://nextbluegeneration.eu/
- The Mediterranean quest "TO "FIND THE BLUE". (n.d.). BLUE SCHOOLS MED. https://www.blueschoolsmed.eu/

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IOC-UNESCO (2022) A new blue curriculum—A toolkit for policy makers. IOC Manuals and Guides, 90

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