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Diving into the ocean literacy paradigm in schools: themes, approaches and impacts

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Abstract

One of the main avenues for developing ocean literacy within communities is to incorporate it into the education of young generations, considering their immediate influence on their peers and family, as well as their future impact as adult citizens. However, the approach to marine issues in schools appears inadequate to accomplish the main goal of ocean literacy, requiring the identification of its major gaps. This study characterizes the current pedagogical approaches and topics related to ocean literacy in Portuguese schools and identifies potential developments in both. It also aimed to determine the impact of ocean literacy activities on the knowledge of elementary school students. Students of 11 classes completed questionnaires with closed and open-ended questions about their attitudes, awareness and knowledge of ocean literacy, before and after an environmental education activity. 70 teachers were sent surveys with closed and open-ended questions about the most chosen ocean topics and pedagogic methodologies when addressing ocean literacy, as well as recommendations for tools to improve the implementation of ocean literacy in schools. A moderate level of knowledge was found in elementary students, with the developed activity promoting an overall increase. Their behavior and interest towards the ocean seemed to be relatively high. Teachers held a preference for popular topics, such as ocean pollution, marine biodiversity or sharks, to be approached in their classes. This study found a disparity in the pedagogic approaches used by teachers when addressing ocean literacy and when addressing general non-ocean related topics, having much less autonomy with the former. Specialized teacher training, bigger expert support and the creation of digital classroom tools were mentioned by educators as improvements needed to improve the approach of ocean literacy in schools.

Keywords: Elementary school, Environmental Education, Informal education, Ocean Literacy, Teaching methods

Resumo

A Literacia do Oceano é um conceito definido como "a compreensão da influência do Oceano em nós e da nossa influência no Oceano", tendo como objetivo criar indivíduos capazes de compreender conceitos fundamentais sobre o oceano e a sua importância para o Homem, comunicar sobre o mesmo de forma consciente e tomar decisões informadas para promover uma sociedade mais azul. Desde a sua criação, tem-se verificado um esforço crescente para melhorar a literacia do oceano a nível mundial. Uma das formas de desenvolver a literacia do oceano dentro da sociedade é a incorporação da mesma em contexto escolar, tendo em conta o impacto dos jovens nas decisões do futuro, para além do efeito intergeracional imediato que estes podem exercer nas suas famílias e conhecidos. Portugal, no seu currículo escolar, pretende pôr em perspetiva a importância do oceano e a forma como interagimos com ele, com o objetivo de criar gerações futuras informadas sobre as ameaças ao oceano e capazes de pensar criticamente sobre a forma como essas ameaças influenciam a sociedade. Para além dos esforços feitos no âmbito do currículo português para incluir a literacia do oceano nas escolas, estas procuram cada vez mais ativamente programas que incluam atividades educativas centradas em ciências marinhas. No entanto, mesmo considerando as medidas adotadas para melhorar a abordagem da literacia do oceano nas escolas, Portugal continua a abordar esta temática de forma recreativa, e não tanto enquanto peça formativa com interesse para o desenvolvimento cívico-ambiental dos alunos. Adicionalmente, bibliografia prévia cita, em cidadãos, uma falta de conhecimento de temas do oceano para além de temáticas conhecidas, como poluição marinha ou sobrepesca, tal como uma falta de confiança no impacto positivo das suas ações individuais.

Colmatar quaisquer lacunas presentes na abordagem da literacia do oceano nas escolas é uma das formas de dar à próxima geração uma melhor compreensão do oceano e do seu impacto sobre o mesmo. Desse modo, um dos objetivos desta dissertação passa por averiguar se a literacia do oceano é encarada e trabalhada nas escolas de uma forma que cumpra eficientemente o seu papel enquanto peça de formação e responsabilização das próximas gerações. De igual forma, é esperado que seja efetuada uma caracterização geral das metodologias utilizadas na abordagem de literacia do oceano em contexto escolar, detalhando o seu estado atual e possíveis progressos a realizar no futuro. Por último, esta dissertação pretende perceber o impacto das atividades de literacia do oceano abordadas em contexto escolar, tanto no conhecimento em alunos como em professores do ensino básico.

Perante estes objetivos, foram colocadas seis questões de investigação: 1) Quais os temas mais abordados no âmbito da Literacia do Oceano nas escolas? 2) O que motiva a escolha de temas no âmbito da Literacia do Oceano nas escolas? 3) Que tipo de metodologias pedagógicas são utilizadas pelas escolas para abordar os temas da Literacia do Oceano? 4) Quais as lacunas que alunos e professores sentem relativamente à abordagem de temas de Literacia do Oceano em contexto escolar? 5) Que conhecimentos têm os alunos do ensino básico no âmbito das temáticas abordadas na Literacia do Oceano? 6) Atividades abordadas em contexto escolar conseguem promover conhecimento dessas temáticas em alunos?

De forma a responder a estas questões de investigação, 220 alunos pertencentes a 11 turmas responderam a um questionário composto por questões abertas e fechadas relacionadas com as suas atitudes, perceções e conhecimentos de literacia do oceano. Os questionários foram realizados antes e depois da realização de uma atividade de educação ambiental "O Oceano é uma grande casa", pertencente ao programa educativo do centro de investigação MARE, "O MARE vai à escola". A atividade foi realizada para estas 11 turmas entre o dia 19 e 26 de abril de 2023, sendo analisados questionários de 183 alunos. Para avaliar se a atividade mencionada acima provocou uma mudança significativa nos conhecimentos dos alunos, os seus questionários foram sujeitos a testes Kruskal-Wallis, para se compararem as

frequências de resposta correta no pré e pós-teste. Os testes estatísticos foram realizados com o auxílio do software R e R Studio. Aos professores que requisitaram atividades do programa educativo "O MARE vai à escola" no ano letivo 2022/2023, foi também enviado um outro questionário para o qual se obtiveram 70 respostas. Este questionário era composto por questões fechadas (escolha múltipla e escala de Likert) e uma questão aberta, sobre os temas e metodologias pedagógicas mais escolhidos na abordagem da literacia do oceano pelos professores nas suas aulas, bem como recomendações de ferramentas que permitam melhorar a implementação da literacia dos oceanos nas escolas.

Foi verificado um nível moderado de conhecimentos e perceções relacionados com literacia do oceano por parte dos alunos, tendo a atividade desenvolvida promovido um aumento de ambos. Os alunos demonstraram interesse em saber mais sobre biodiversidade marinha, especificamente mamíferos marinhos e peixes. Adicionalmente, mostraram interesse em melhorar os seus comportamentos perante o ambiente, pedindo conselhos para atitudes sustentáveis que possam ser aplicadas diariamente. Os professores demonstraram uma preferência por atividades associadas a temas em voga na sociedade, como por exemplo poluição marinha, biodiversidade marinha ou sobre tubarões, um grupo de animais carismático. Foi verificada uma falta de conhecimento de temas de literacia do oceano por parte dos professores, com exceção de temas populares ou aqueles presentes no currículo português. Esta falta de conhecimento está acoplada a uma abordagem exclusiva aos temas que os professores conhecem. Este estudo identificou também uma disparidade nas metodologias pedagógicas utilizadas pelos professores quando abordam a literacia do oceano e quando abordam temas não relacionados com a mesma. Os professores tendem a abordar temas gerais maioritariamente em aula de forma autónoma, enquanto a sua abordagem de temas sobre o oceano possui um espetro de metodologias pedagógicas muito variado, como por exemplo atividades realizadas por especialistas, saídas de campo a aquários, zoos ou ambientes naturais, existindo uma redução notável na autonomia dos professores. Esta falta de autonomia poderá ser explicada pelo conhecimento mediano em ciências marinhas verificada não apenas no presente estudo, mas também em estudos prévios. O currículo português pesado poderá também explicar este défice de autonomia, ao sobrecarregar os professores e os dissuadir de abordar, por si mesmos, temáticas fora do currículo nas suas aulas. Formações para professores destinadas a melhorar conhecimentos de literacia do oceano e a aplicação desses conhecimentos nas aulas foram mencionadas como a principal ação necessária para a melhoria desta área em contexto escolar, bem como um maior apoio de especialistas e a criação de ferramentas digitais. Estudo prévios apoiam estes resultados, identificando o currículo saturado, a falta de conhecimento acerca do ambiente marinho por parte dos professores e a carência de recursos educativos relacionados com o oceano como os principais desafios à sua integração nas escolas portuguesas.

Entidades de Educação Ambiental são incentivadas a implementar e a divulgar ainda mais as suas atividades de ciências marinhas no futuro, tentando: 1) utilizar a popularidade das espécies ou temas mais conhecidos para abordar os de menor notoriedade; e 2) educar os alunos sobre comportamentos ecológicos concretos que estes podem adotar diariamente, a fim de os empoderar e aumentar a sua confiança no seu comportamento individual. Estas entidades são igualmente incentivadas a desenvolver formações direcionadas a professores, de forma a melhorar o conhecimento de literacia do oceano dos mesmos e os capacitar com formas de abordar esses conhecimentos nas suas aulas, autonomamente. Por fim, é da responsabilidade do governo melhorar o nível de literacia do oceano nas escolas portuguesas, sendo recomendado uma maior inclusão das ciências do mar no currículo português, bem como tornar estes temas obrigatórios na disciplina de educação para a cidadania.

Palavras-chave: Educação Ambiental, Educação informal, Escola primária, Literacia do Oceano, Métodos de ensino

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List of abbreviations, acronyms and symbols

EE - Environmental Education

EMSEA - European Marine Science Educators Association

EU - European Union

IPCC - Intergovernmental Panel on Climate Change

MARE - Centro de Ciências do Mar e do Ambiente (Marine and Environmental Sciences Center)

MVE - O MARE vai á escola

NGO - Non-Governmental Organization

NMEA - National Marine Educators Association

OL - Ocean Literacy

OLPs - Ocean Literacy Principles

OOM - Observatório Oceânico da Madeira

SDG - Sustainable Development Goals

SG - Strategic Goals

UN - United Nations

UNESCO - United Nations Educational, Scientific and Cultural Organization

1. Introduction

The ocean is the body which makes our planet inhabitable (Cava *et al*., 2005). It covers around 70% of the Earth's surface and produces more than 50% of the oxygen present in the atmosphere, as well as regulates the climate and supports a vast diversity of habitats, resources and life (Cava *et al.*, 2005; Fauville *et al.*, 2019). Despite this, the ocean continues to be one of the environments most affected by human activity, especially in coastal areas (Lubchenco *et al.*, 2016), with ocean acidification, ocean warming (IPCC, 2014) and loss of habitats and biodiversity (Stoll-Kleemann *et al.*, 2019) the most significant impacts worldwide. With the ongoing population growth and subsequent increase in the occupation of coastal areas, the negative ocean impacts are expected to persist over the next decades (IOC-UNESCO, 2020).

In this context, the European Union (EU) created the Blue Growth Strategy, which established the importance of protecting the ocean, arguing that the development of ocean activities for all different emerging maritime sectors (aquaculture, tourism, deep-sea mining, etc) should be sustainably implemented (Brennan *et al.*, 2019). Additionally, the United Nations (UN) implemented the UN Decade of Ocean Science for Sustainable Development 2021-2030, which emerged as a unique opportunity for the member states to find and implement solutions to the current state of degradation of the ocean and marine ecosystems (UNESCO, 2022). Also, the 2030 Agenda for Sustainable Development, which defines the priorities and aspirations for the sustainable development for 2030, has been proposed, being composed of 17 Sustainable Development Goals (SDGs), including 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" (UNESCO, 2017). To achieve these goals, society must have a general understanding of their daily impact on ocean health and the effects of the ocean on their own lives (Ashley *et al.*, 2019). Ocean literacy (OL) is therefore important in educating society about important themes such as ecology, climate change, biodiversity and sustainable development (Santoro *et al.*, 2017).

OL is a concept which arose in the United States of America around 25 years ago, following a collaboration involving scientists, educators and policymakers about people's lack of knowledge and awareness on ocean and marine issues, the lack of topics in school curricula and the need to face these challenges (Cava *et al.*, 2005; Schoedinger *et al.*, 2005; Costa e Caldeira, 2018). This concept can be defined by the "understanding of the ocean's influence on you, and your influence on the ocean" (Cava *et al.*, 2005), with the goal of educating individuals capable of understanding fundamental concepts about the ocean and its importance, communicate about it in a meaningful way and making informed and responsible decisions regarding this environment and its resources (Cava *et al.*, 2005; Brennan *et al.*, 2019; Mogias *et al.*, 2019).

From this definition, Cava *et al.* (2005) stated 7 Ocean Literacy Essential Principles (OLPs), with 44 fundamental concepts:

- Principle 1 The Earth has one big ocean with many features;
- Principle 2 The ocean, and life in the ocean, shape the features of Earth;
- Principle 3 The ocean is a major influence on climate and weather;
- Principle 4 The ocean made the Earth habitable;
- Principle 5 The ocean supports a great diversity of life and ecosystems;
- Principle 6 The ocean and humans are inextricably interconnected;
- Principle 7 The ocean is largely unexplored.

Since its creation, there has been a growing effort to improve OL on a global level (Dupont & Fauville, 2017; Fauville *et al.*, 2018a). However, having its origin in the United States, OL was dominated by a single country for most of its existence, and until 2012 only the US had articles and conferences related to this topic (Costa & Caldeira, 2018). That year, the National Marine Educators Association (NMEA), the American association responsible for creating the 7 OLPs, endorsed the creation of the European Marine Science Educators Association (EMSEA), leading the EU to adopt the OLPs and commit to the development of OL in the EU (Brennan *et al.*, 2019). Since then, there has been an overall growth in the approach to OL in Europe, with the United Kingdom leading this boom (Costa & Caldeira, 2018). However, Portugal has been a major contributor to this goal in Europe, becoming, in 2011, the first country to translate and adapt the OLPs to the Atlantic reality, as well as the first to adopt a model aimed at raising awareness within the younger generations with the creation of the "Conhecer o Oceano" ("Know the Ocean") project (Costa *et al.*, 2020; Ciência Viva, n.d.).

The UN mentions SDG 4 in the 2030 Agenda for Sustainable Development, which advocates for the existence of primary and secondary education for every boy and girl in the world, in addition to eliminating gender and socio-economic disparities and providing access to universal higher education (UNDP, n.d.). Environmental Education (EE), as first coined by Stapp *et al.* (1969), is an approach to education which has the goal of "producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution". Moreover, "EE should be accessible to all, providing opportunities for every citizen to improve their knowledge regarding the natural world, and the ways to protect it, engaging society to contribute in its protection" (UNESCO-UNEP, 1978; Aurélio *et al.*, 2021). In order to develop OL within communities, one of its main objectives is to be incorporated into the education of young generations, since they will be faced with the impacts caused by climate change, just as they will be the ones to make decisions about the future, whether through everyday attitudes or political decisions (Körfgen *et al.*, 2017; Mogias *et al.*, 2019). Thus, EE is a very important vehicle for presenting these issues to young people in a school context, with Ballantyne *et al.* (2001) highlighting the greater reach that EE programmes have not only for pupils, but also for the rest of society, through the communication of enthusiastic children with their parents or other adults in their family and social circles.

In Portugal, the importance of OL was quickly recognized, being one of the first countries to integrate it into the school context (Santoro *et al.*, 2017; Costa & Caldeira, 2018). In addition, in August of 2021, Portugal established the National Strategy for the Sea 2021-2030 Action Plan, which includes 185 goals grouped into 10 Strategic Goals (SGs). SG 8, in particular goals 112, 121, 123 and 124, mentions the importance of developing OL in schools, whether by building integrated strategies, integrating a national education programme for the sea or promoting the exchange of cultural and historical heritage of the sea (DGPM, n.d.).

In the Portuguese curriculum, it's possible to see the attempt to implement ocean-related content in schools. The curriculum in both elementary and middle school aims to put into perspective the importance of the ocean and how we interact with it, to promote the discovery of marine biodiversity and ocean goods and services, as well as to create future generations informed about the threats to the ocean and capable of thinking critically about how these threats influence society (Monteiro *et al.*, 2021; DGE, n.d.-a). In addition, the subject of citizenship education has several domains intended to be addressed in a school context on an ongoing basis throughout the school year. One of these domains concerns EE, which includes topics related to OL (DGE, n.d.-b).

In addition to the efforts made within the Portuguese curriculum to include OL in schools, schools are also more actively seeking out programmes that include education activities focused on marine science. Portugal is an international success story with the “Blue School”, pioneering the creation and implementation of this programme in the “All Atlantic Blue Schools Network” (All Atlantic Blue Schools Network, n.d.). The “Blue School” is an educational programme run by the Ministry of the Economy and the Sea that "distinguishes and guides schools that work on issues related to the sea, creating a community that brings together schools, the maritime sector, industries, municipalities, NGOs, universities and other entities with an active role in Ocean Literacy" (Escola Azul, n.d.). It aims to bring together all OL activities in Portugal under the same umbrella (IOC-UNESCO., 2022).

There are currently around 100 Blue School partners, including the Marine and Environmental Sciences Center (MARE), with its official educational programme, "O MARE vai à escola" (MVE). MVE emerged from MARE's desire to promote dialogue between researchers and society through clear, simple and dynamic communication, contributing to an interested, participatory and knowledgeable "Blue Society". The programme has the following goals:

- to increase OL levels in society;
- to promote the implementation of OLPs in Portuguese school curricula;
- to raise awareness towards the importance of the ocean;
- to contribute to a participatory blue society;
- to tighten relationships between the scientific communities and Portuguese schools;
- to raise awareness of the consequences of human behaviour on natural systems;
- to inform about good practices applicable to the marine environment and its natural resources;
- to publicize MARE and its role as an important national and international research unit.

Using entertaining, interactive and creative activities in informal contexts, MVE explores topics such as ocean biodiversity, aquatic organism adaptations, marine trophic relationships, conservation, exploitation and integrated management of marine resources, and humanity's role in sustainable development. These educational activities, which include hands-on or laboratory activities, as well as guided tours, are available to schools for free, on an appointment basis, with many applying to the programme each academic year (O MARE vai à escola, n.d.).

However, even considering the steps taken to improve the approach to OL in schools, there are still some gaps. Mogias *et al.* (2019) mention that, in studies carried out in the United States and Europe, there was a high level of concern and interest in topics such as pollution, industrial toxic waste and overfishing, but low knowledge of other ocean-related topics, such as ocean acidification, as well as low confidence in the impact of their individual actions. Additionally, about marine biodiversity, there is a notable focus on marine animals compared to plants (Jefferson *et al.*, 2014), and even amongst the animal kingdom there seems to be a focus on vertebrates over invertebrates, despite the importance and prevalence of the latter (Costa *et al.*, 2021). In Portugal, despite the efforts made, EE, and consequently OL, continues to be taught as a recreational activity and not so much as the main objective of a formative piece, sometimes being taken simply as an extracurricular activity without due relevance as a mechanism for students' civic and environmental responsibility (Schmidt *et al.*, 2010).

Given this disparity of topics observed in the literature and considering the recreational and/or optional approach that ocean themes have in Portuguese schooling, it is important to identify gaps in the topics taught and in the way they are covered, and to realize how more attention and seriousness can be given to the topics less taught.

2. Objectives

Improving the approach to different OL topics in Portuguese schools, especially less covered ones, is one of the ways to give the next generation a better understanding of the ocean and their impact on it, giving them a greater responsibility towards its preservation, as well as being able to promote behavioural changes in those close to them.

Therefore, the main goal of this dissertation is to find out whether OL is seen and worked on in schools in a way that efficiently fulfils its role as a tool for educating and empowering the next generations.

Moreover, it is expected to provide a general characterization of the approaches (pedagogic methodologies employed) to OL issues in a school context, detailing their current state and possible improvements to be made in the future.

Lastly, this dissertation aims to understand the impact of OL activities addressed in a school context on the knowledge of elementary school students.

Given these objectives, six research questions were asked:

1. What topics are most addressed in the context of OL in schools?
2. What motivates the choice of OL topics in schools?
3. What kind of teaching methodologies do schools use to address OL issues?
4. What gaps do teachers feel there are in addressing OL issues in the school context?
5. What knowledge do elementary school students have regarding the topics covered in OL?
6. Do OL activities in a school context succeed in promoting knowledge of these themes in elementary school students?

To answer these questions, this study applied a questionnaire to elementary school students before and after conducting an educational activity, in order to measure their knowledge, interests and attitudes. Additionally, a questionnaire was applied to teachers who previously requested MVE activities, in order to characterize the OL topics approached in educational activities and the methodologies used for teaching these issues in schools, as well as to detail possible improvements for the future.

3. Materials and methods

3.1 Students

Two hundred and twenty students participated in the present study, belonging to 11 different classes of the third and fourth grades, ranging from 8 to 12 years old, from three different schools in Barreiro (Setúbal, Portugal) region. In each grade, two classes were selected for the study in both schools A and B, while for school C two classes from the fourth grade and one from the third grade were chosen.

Table 3. 1 - Number of students from every class (represented by C1 through C11) present in the study.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
School A	17	20	21	19	–	–	–	–	–	–	–
School B	–	–	–	–	14	18	17	10	–	–	–
School C	–	–	–	–	–	–	–	–	13	19	15

3.1.1 Experimental design

The methodology used in this study was divided into a three-step process:

(1) students were asked to fill out a pre-test questionnaire related to the themes of the activity they would be participating in, i.e. marine biodiversity, to measure their prior knowledge on this topic, their views on OL and their attitudes towards the ocean.

(2) immediately following the pre-test questionnaire, the activity "O Oceano é uma grande casa" ("The Ocean is a big home"), from the educational programme MVE, was presented to the students of every class.

Both the pre-test questionnaire and the activity were completed within one week, between the 19th and 26th of April 2023, for all the classes.

(3) the students were asked to fill out a post-test questionnaire, three to four weeks after the activity was presented, between the 15th and 17th of May 2023, in order to measure changes in the student's knowledge and views.

3.1.2 Questionnaire

As previous research has shown the benefit of using both closed and open-ended questions in questionnaires in EE and OL studies (Creswell, 2009; Neuman, 2013; Boaventura *et al.*, 2021; Aurélio *et al.*, 2022), this was the approach applied in the present study.

The questionnaire (ANNEX 1) was divided into three sections: "habits and perspectives", "knowledge" and "appreciation", the latter existing only in the post-test questionnaire.

The "habits and perspectives" section was comprised of 7 closed questions, using either multiple choice or Likert scale, all of them related to the student's appreciation towards the ocean, how they contact

with it, as well as their concern, communication, and attitudes regarding ocean impact. This was performed similarly to Brennan *et al.* (2019), in which questions were generally assigned to certain OL dimensions (awareness, attitude, behavior, and communication).

The "knowledge" section contained 10 multiple choice questions related to the topics addressed in the "Oceano é uma grande casa" activity, following its main pedagogic objectives detailed in the MVE activity mentioned further below.

The "appreciation" section of the questionnaire was primarily focused on one Likert scale question and three short open-ended questions evaluating the students' appreciation of the activity, specifying their favorite and least favorite aspect of the activity, as well as topics they would be interested in having addressed in the future.

The questionnaire aimed at a 20-30 minute completion time, following the recommendations in Brennan *et al.* (2019). Before being applied in the actual study, the questionnaire went through a validation process with 9 third and fourth-grade students, not associated with the study, to assess if the questions, language, and duration of the questionnaire were appropriate to the audience.

3.1.3 "MARE vai à escola" activity

The activity was designed for the educational programme MVE in 2015, with the following objectives:

- Highlight the different ocean ecosystems, their characteristics, and importance for the environment;
- Describe the great diversity of organisms present in the ocean, as well as the defining characteristics of each group of organisms (birds, reptiles, fish, algae, etc);
- Identify which fish species, present on the Portuguese coast, are important to our diet;
- Emphasize the plethora of reproduction and feeding strategies used by ocean organisms, as well as various adaptations to the aquatic environment they live in;
- Raise awareness of the anthropogenic impacts on the ocean, as well as guidelines for environmental-friendly daily attitudes.

The first part of the activity consisted of a PowerPoint presentation with a theorical and descriptive approach, in which students were taught topics related to the objectives presented above, with visual support such as images or videos to more clearly familiarize them with marine biodiversity, while encouraging their participation.

The second part of the activity consisted of an interactive quiz, in which students were encouraged to recreationally recall and answer different questions related to the previous presentation, to further consolidate the gained knowledge.

The whole activity had an estimated time of 90 minutes, with 60 minutes being allocated for the descriptive part of the activity, and 30 minutes allocated for the interactive quiz.

3.2 Teachers

A survey, elaborated using the Google Forms platform, was sent to every teacher who requested activities conducted by the educational programme MVE in the 2022/2023 school year, regardless of the chosen activity. The questionnaire was used to understand which ocean topics are most commonly chosen for educational activities and why, as well as to assess what pedagogic methodologies are most used by the teachers to approach these topics in a school context and what improvements could be made to better implement OL in Portuguese schools.

This questionnaire (ANNEX 2), was composed of three sections:

(1) questions related to the teachers' demographic, their level of education, and grade level taught;

(2) closed questions, the majority involving the Likert scale, related to the MVE programme and its activities, as well as their effect on teachers and students alike;

(3) questions related to the teachers' autonomy in the teaching of ocean themes, the pedagogic methodologies chosen to tackle these themes, and the shortcomings related to OL in a school context.

Similarly to the students' questionnaire, this went through a validation process with 6 teachers who were not associated with this study, to assess if the questions, language and duration of the questionnaire were appropriate.

The questionnaire was sent to 112 teachers on the 4th of June 2023, and remained available for five weeks, until the 14th of July 2023. From the 112 teachers, a total of 70 answered the questionnaire.

3.3 Data processing

Concerning the students' questionnaire, matrixes were created with the Microsoft Excel 2016 software, with each answer given by the students in the "habits and perspectives" and "knowledge" sections, for both the pre and post-test.

Questionnaires from 37 students were removed from the data analysis, due to their absence in the pre and/or post-test questionnaire, or because of filling errors. After this elimination process, questionnaires from 183 students remained for the analyses.

In the "habits and perspectives" section, for the rating scale questions, the answers were marked using the Likert scale (from 1 to 5), with 1 being the most negative answer, and 5 the most positive. For the multiple-choice answers, the answers were marked with 1s and 0s, depending on whether each answer option was selected or not selected, respectively. Afterwards, the frequency for every answer choice was calculated.

In the "knowledge" section, to all the 10 questions, each correct answer was worth 1 point, with the maximum possible grade of 10 points. The final score of every student regarding this section was calculated, and the total student average for the pre and post-test was determined.

For the teachers, Excel matrixes were also created according to their answers to the questionnaire.

Similarly to the students, the Likert scale was used for the rating scale questions, and for the multiple-choice questions, whether they had only one answer choice or multiple possible choices, the frequency for each answer was calculated.

For the open-ended questions included in both questionnaires, the answers were categorized and grouped based on the similarity of the themes. Afterwards, for each theme, the frequency of answers was calculated.

3.4 Data analysis

Using the Microsoft Excel 2016 software, an exploratory analysis of the data was performed.

For both the questions included in the "habits and perspectives" and the "knowledge" section of the students' questionnaire, a Shapiro-Wilk normality test was conducted, in which it was possible to infer the data did not follow a normal distribution. As so, Kruskal-Wallis tests were performed to compare pre- and post-test frequency of answers related to the student's attitudes and values towards the ocean, to assess if the educational activity performed in the study had any effect on these elements.

Additionally, the Kruskal-Wallis tests were used to compare the pre- and post-test frequency of correct answers in the "knowledge" section, as well as the final grade of the questionnaire, in order to assess if the aforementioned activity caused a significant change in students' knowledge. These analyses were conducted using the R (R Core Team, 2023) and R Studio software (Posit Team, 2024).

4. Results

4.1 Students

One hundred and five of the 183 students in the study were male, with the remaining 78 being female.

4.1.1 Habits and perspectives

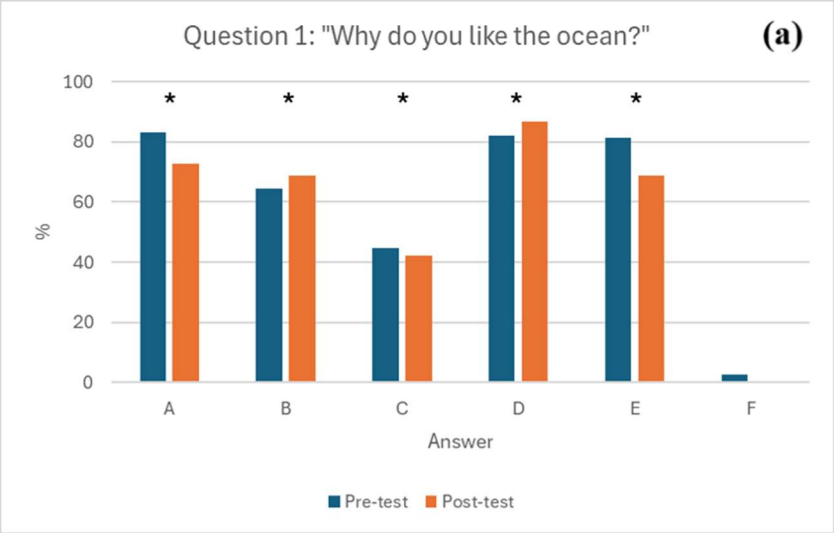
Comparing the results of the pre- and post-test questionnaire obtained, in question 1 "Why do you like the ocean?" (Fig. 4.1a), it's possible to see an increase in options such as "Because it's important for life on Earth" (option D) and "Because I like animals" (option B), while other options related to aesthetics and leisure such as "Because it's beautiful" (option E) and "Because I can swim/go to the beach" (option A) have suffered a decrease. The Kruskal Wallis tests revealed that changes in all answer options were statistically significant ($p < 0,05$), except for the option "I don't like the sea" (Option F) ($p = 0,8669$).

In question 2 "Until today, I learned more about the ocean…" (Fig. 4.1b), the option "In class" (Option A) was the most chosen by a large margin, with other options such as "When I go to a beach/river/lake" (Option H) or "In field trips (zoo/aquariums/etc)" (Option G) also being relatively prevalent options. The latter was subject to a very large increase in the post-test. All the differences registered were statistically significant ($p < 0,05$).

In question 6, relating to what sustainable or non-sustainable daily attitudes do students normally have, it was possible to observe higher values for sustainable attitudes, such as recycling (option A), cleaning beaches (option C) and not wasting energy with lights sources while at home (option F), and low values for non-sustainable ones, like frequently running long showers (option B), leaving water running while brushing their teeth (option D) and buying plastic bags while shopping (option E). Moreover, a statistically significant increase ($p < 0,05$) in the post-test was observed for most of the sustainable attitudes and a decrease for the non-sustainable ones (Fig. 4.1c).

In question 7, an overall increase in awareness of the presented ocean themes was observed in the post-test, with especially high increases for "marine biodiversity" (option G) and "ocean literacy" (option A). The highest values of awareness were observed for "habitat destruction" (option F) and "marine pollution" (option C) (Fig. 4.1d). All the differences obtained in this question were statistically significant ($p < 0,05$).

Questions 3, 4 and 5, which concerned the "attitude" and "communication" dimensions of OL, suffered a slight, but statistically significant ($p < 0,05$) decrease in the post-test (Fig. 4.1e).



A – Because I can swim/go to the beach

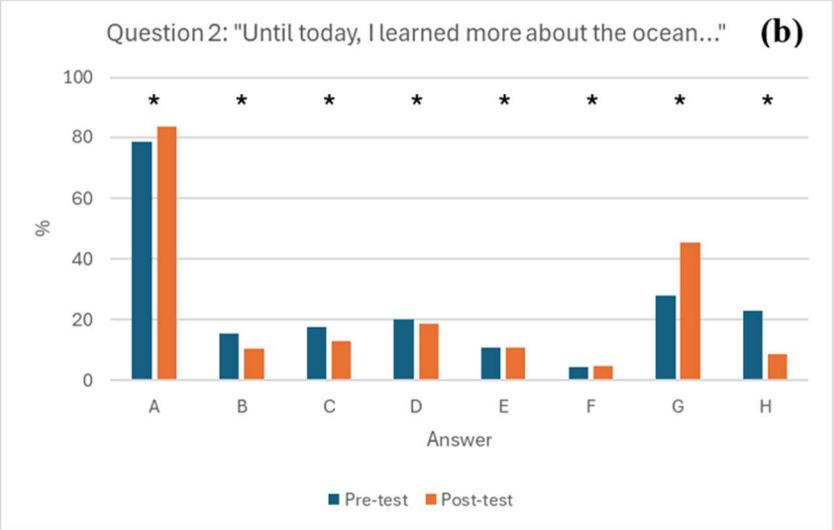
B – Because I like animals

C – Because it gives me food

D – Because it's important for life on Earth

E – Because it's beautiful

F – I don't like the ocean



A – In class

B – On the internet

C – Reading books at home

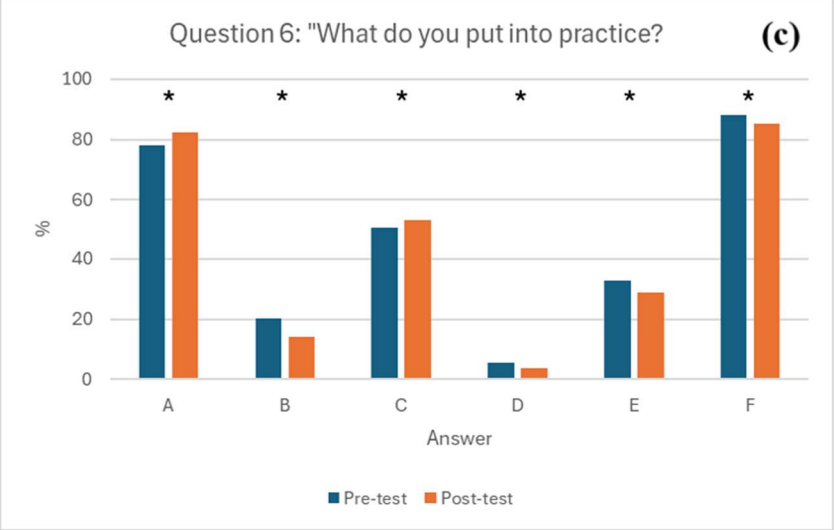
D – With my family

E – Watching TV

F – Playing videogames

G – In field trips (zoo/aquariums/etc)

H – When I go to a beach/river/lake



A – I recycle

B – I take long showers frequently

C – I pick up garbage on the beach

D – I leave the water running while brushing my teeth

E – I buy plastic bags when shopping in supermarkets

F – I turn off the lights when I leave the rooms in my house

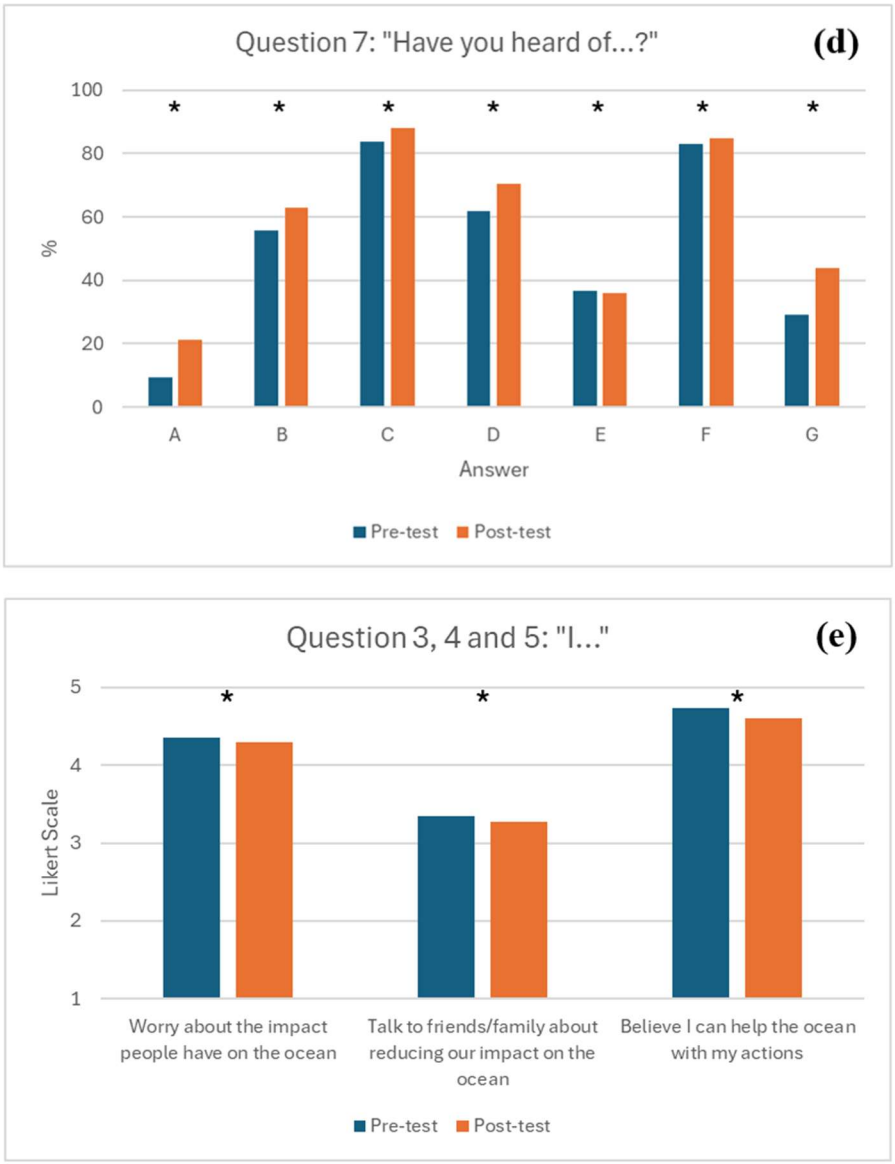


Figure 4. 1 - Relative answer frequencies of every question in the "habits and perspectives" section for the pre and post-test of the questionnaire. Marked with "*" are the answers or answer options in which a statistically significant change was observed ($p < 0,05$)

4.1.2 Knowledge

Considering the non-normal distribution of the data found using the Shapiro-Wilk test (Pre-test: $W = 0.9579$, $p < 0,05$; Post-test: $W = 0.91143$, $p < 0,05$), in order to verify the existence of statistically significant differences between the pre and post-test in the knowledge section, a Kruskal-Wallis test was applied.

When analyzing the overall scores relating to the 10 questions, each worth one point, of the knowledge section, a statistically significant increase between the pre and post-test was found ($H = 66.811$, $p < 0,05$), with the average grade changing from 6,175 to 7,383 out of 10 possible points (Fig. 4.2).

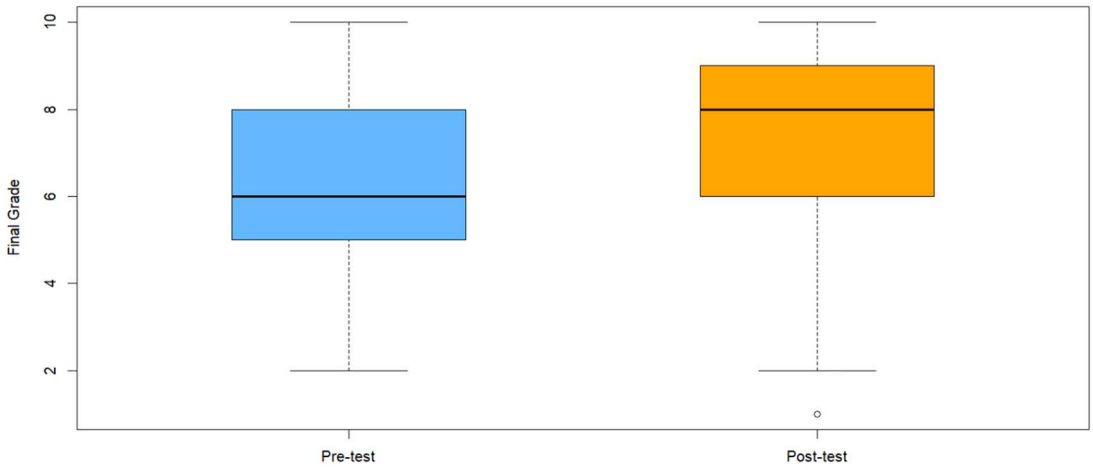


Figure 4. 2 - Comparison between the results of the pre-test and the post-test for the "knowledge" section of the students' questionnaire. Pre-test: Median = 6, First and third quartile = 5 and 8; Post-test: Median = 8, First and third quartile = 6 and 9.

In addition to the increase in the students' average score, each individual question had a statistically significant increase in correct answers in the post-test (Figure 4.3; $p < 0,05$), except for question 10 "Who breathes underwater?" ($p = 0,9581$). The most correctly picked answers were Q8 "The Earth is called the Blue Planet because…", Q9 "Which of the following is not a living being?", Q10 "Who breathes underwater?", Q14 "The oceans are all different, but they're all connected", Q16 "In the ocean there are living beings, very important to us, so small they can't be seen". An especially high increase was seen in question 15 "To keep themselves warm, marine mammals can have a layer of fur or fat", which double the correct answers in the post-test.

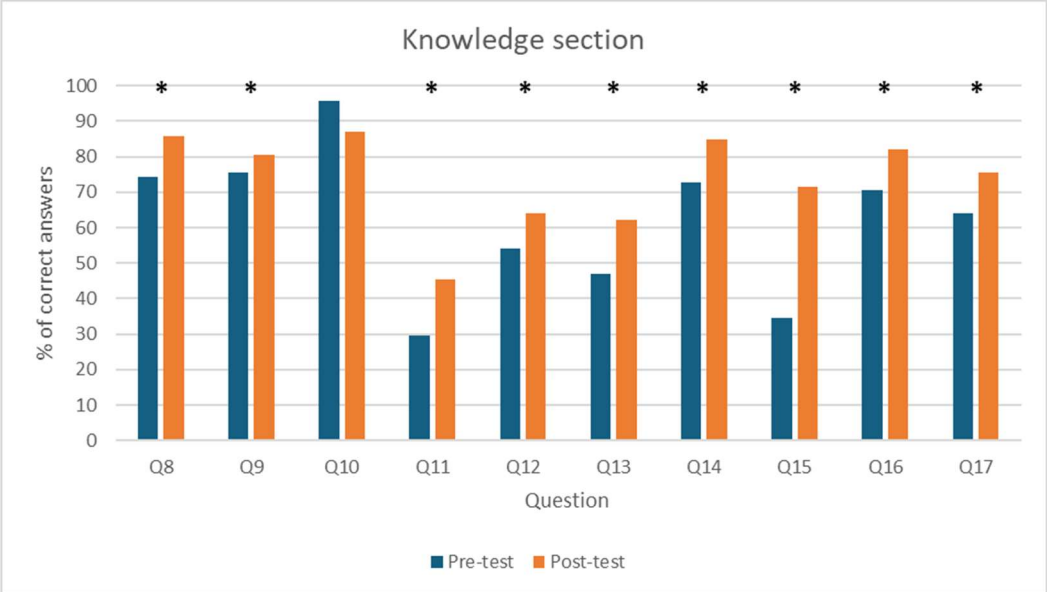


Figure 4. 3 - Relative frequency of correct answers for every question in the "knowledge" section for the pre and post-test of the student questionnaire (Q8 – "The Earth is called the Blue Planet because:", Q9 – "Which of the following is not a living being?", Q10 – "Who breathes underwater?", Q11 – "What is the difference between reptiles and amphibians?", Q12 – "Which of these groups of animals don't lay eggs?", Q13 – "Invertebrates have bones, unlike vertebrates, which have no bones.", Q14 – "The oceans are all different, but they're all connected.", Q15 – "To keep themselves warm, marine mammals can have a layer of fur or fat.", Q16 – "In the ocean there are living beings, very important to us, so small they can't be seen.", Q17 – "All marine animals search for food in the same way.". Marked with "*" are the answers in which a statistically significant change was observed ($p < 0,05$).

4.1.3 Appreciation

In general, students saw the activity as a positive experience, with the “appreciation” question scoring an average of 4,60 out of 5.

When asked about what they liked the most, the majority answered that they enjoyed learning more about marine biodiversity, as well as the interactive quiz at the end of the activity.

When asked about what they enjoyed the least, most of the students had nothing to add, but some mentioned aversion to certain types of marine animals shown in the activity.

When asked about what they would like to learn in future activities, many students pointed out marine biodiversity, with a specific focus on fish and marine mammals. Furthermore, they also would like to seek for advice towards more environmentally friendly precautionary attitudes.

4.2 Teachers

Most teachers who answered to the questionnaire were women (90%), with ages between 40 to 59 (88,6%).

Almost all of the teachers (85,7%) had completed a bachelor's degree, while some (8,6%) had also completed a master's degree.

Half of the teachers were from elementary school, while the rest were either middle-school (37,1%) or high school teachers (11,4%).

4.2.1 "MARE vai à escola" activities

The most chosen activities from the MVE programme in the 2022/2023 school year were related to ocean pollution (31,4%), marine biodiversity (21,4%) and sharks (20%). It was also possible to see the success of the "O MARE vai à praia" (19%) and "Biólogo por um dia" (19%) activities, both hands-on interactive activities.

When asked about the factors for choosing their respective MVE activities, the teachers selected "current theme", "increase of knowledge of the class", "development of citizenship skills" and "direct interactions with researchers" as the factors with the most importance, while "freeing up the teacher for other activities" had many differing answers in terms of its importance (Fig. 4.4).

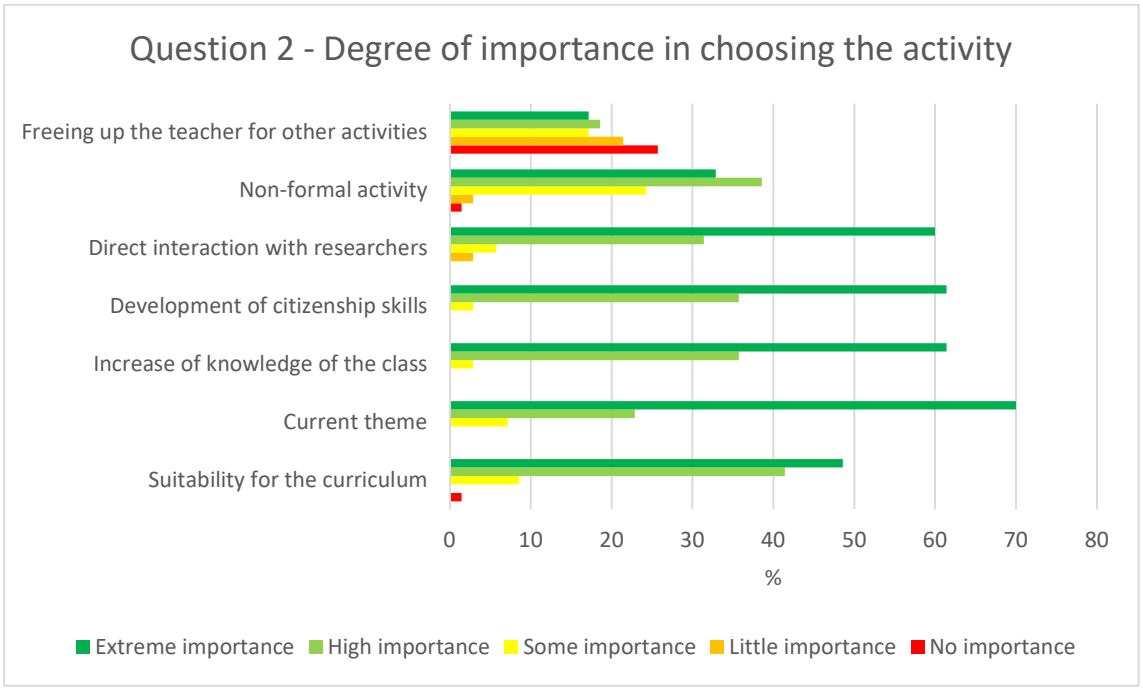


Figure 4. 4 - Answer frequencies of question 2, relating to the main factors for teachers in their choice of the respective MVE activities in the 2022/2023 school year.

In question 3, teachers believed that the MVE activities changed the students' interests, knowledge and attitudes regarding the approached ocean topics in a positive way. However, teachers seemed to think the student's attitudes were not as positively affected as their knowledge and interests.

Additionally, in question 5, teachers revealed the activities had created in themselves a considerable interest to develop OL activities on their own.

Most teachers discovered the MVE programme by recommendation of another colleague (37,1%) or by social media (20%), as well as having discovered the programme through another EE entity (12,9%) or MVE's mailing list (10%).

Less than half (41%) of the teachers had participated in activities from other educational programmes, with "Oceanário de Lisboa" (22,9%), "Escola Azul" (Blue School) (8,3%) and "Associação Bandeira Azul de Ambiente e Educação" (formerly ABAE, now ABAAE) (8,3%) being the most sought-after programmes within these teachers (Fig. 4.5).

Figure 4. 5 - Wordcloud describing the educational programmes and entities besides MVE that teachers have participated in.

4.2.2 Ocean Literacy in a school context

According to answers given in question 7, teachers claim teaching ocean-related themes frequently in classes, and in question 10, when asked about their confidence in teaching these themes, many expressed feeling "confident" (39%), "very confident" (43%), or even "extremely confident" (11%), with a smaller portion (7%) presenting lower confidence in their autonomy. Furthermore, around 70% answered they are aware of the official definition of OL.

When asked which of the 16 presented ocean terms they could define, around half of the teachers (47%) could not define more than half of the 16 terms, with about a quarter (27%) able to define 5 or less. However, a quarter of the teachers could define 12 or more terms, with 4 teachers able to define every single term presented. The most known terms were "sustainability", "marine pollution", "water cycle" and "climate change", with more than 80% of teachers able to define them.

When asked about which of the 16 ocean-related themes were taught in their classes, 68% of teachers taught less than half of the concepts, with 35% teaching only 5 or less, and only 8,5% teaching 12 or more ocean concepts in their classes. The most taught themes were also "sustainability", "marine pollution", "water cycle" and "climate change", all of them taught by more than 80% of teachers of this study.

Teachers were asked what kind of pedagogic methodologies were used to approach topics in a school context, for general school topics and for ocean-related topics. For the first, a large proportion (56%) of

teachers selected teacher-led learning as their main pedagogic approach, with student autonomous learning, hands-on and critical thinking activities being picked by around 10% of teachers. However, for ocean-related topics, the results varied greatly: teacher-led learning decreased from nearly 60% to less than 20% of teacher's answers, with other pedagogic approaches more frequently used, like researcher-led activities, field trips to zoos and aquariums, outdoor exploration activities and autonomous student inquiry learning. (Fig. 4.6).

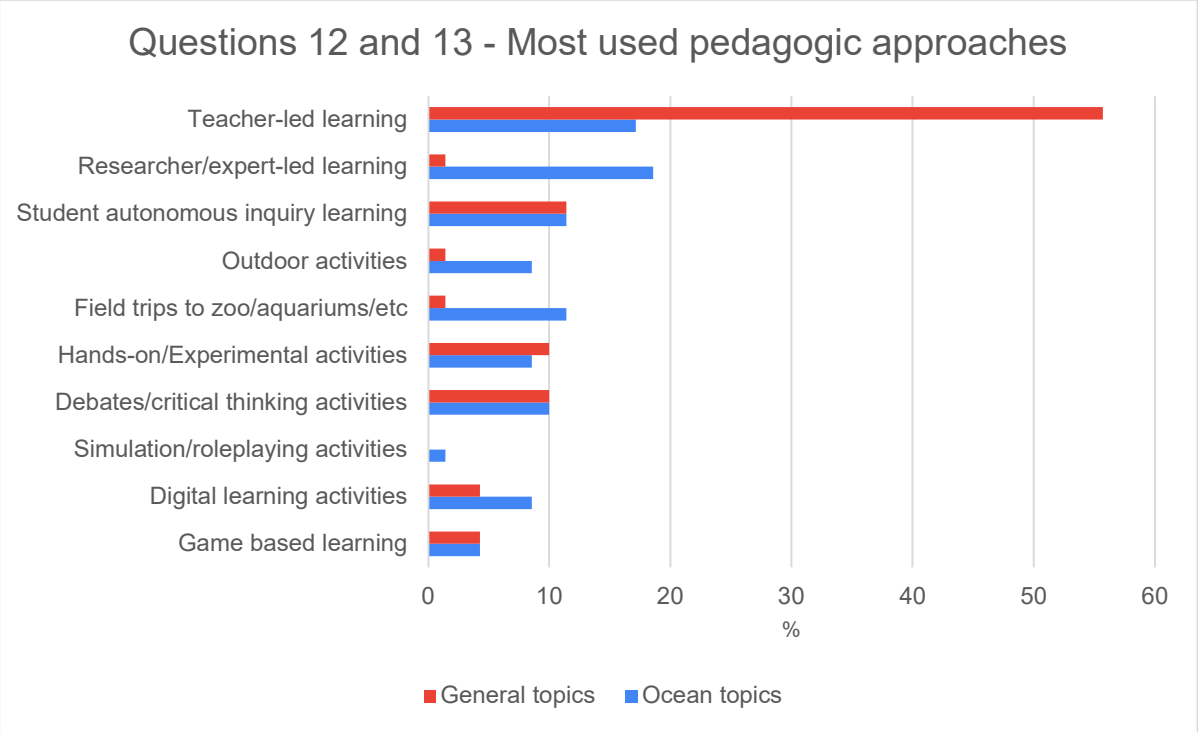


Figure 4. 6 - Answer frequencies for questions 12 and 13, pertaining to the pedagogic methodologies most used by teachers when teaching general topics in a school context (question 12) and when teaching ocean topics in the same context (question 13).

Teachers reported a high level of satisfaction (4,16 out of 5) in the way ocean-related themes are integrated in the school curricula, but when asked what tools would help their competence in teaching them in their classes, specialized teacher training in these topics (57%) and bigger support by experts/researchers (47%) were chosen as main improvements needed in this context. The creation of digital classroom tools (40%), improved knowledge of pedagogic approaches for ocean-related themes (36%) and better peer support in field trips (33%) were also mentioned as other improvements needed to better include and approach ocean-related themes in Portuguese schools.

5. Discussion

5.1 Students

The elementary school students in this study revealed a moderate level of knowledge regarding OL topics, scoring an average grade of 6,175 out of 10 in the knowledge section of the pre-test questionnaire. These findings are in line with previous research on students of the same education levels from other countries, for example, England, Greece, Italy or Croatia (Hartley *et al.*, 2015, Mogias *et al.*, 2015, 2019), in which a moderate level of OL knowledge was also found. Following the activity, the student's knowledge regarding the associated topics improved, as seen by the increase in the post-test results of the knowledge section of the questionnaire. These results are also consistent with the existing research (Cummins & Snivelly, 2000; Hartley *et al.*, 2015; Aurélio *et al.*, 2022), which all identify an increase in student knowledge following similar activities.

The ocean's importance for life on Earth and the students' appreciation for animal life were the two reasons for them liking the ocean that showed the highest increases in the post-test. This result was expected, considering that two of the main objectives of the activity were to foster an interest and appreciation for marine biodiversity and to highlight the importance of the oceans ecosystems to life on Earth. The decrease in options related to leisure and aesthetics may indicate the activity made students understand ocean values beyond superficial, yet important feelings of pleasure and aesthetics (Milne *et al.*, 2010) towards the ocean and appreciating it for its intrinsic value.

Most students stated learning more about the ocean in class, since school is the physical place where students learn the most in a general sense and therefore, about the ocean. Direct experiences, in nature or aquariums and zoos, also seemed to have a big role in educating students about the ocean. For students, such direct experiences can create an interest in science themes and improve their critical thinking and communication relating to science (Bell *et al.*, 2009), as well as creating in them a sense of protection towards ocean biodiversity (Furtado *et al.* 2018), which in turn may improve their attitudes and views towards ocean conservation in the long-term (Ballantyne & Packer, 2011). The seemingly abnormally large increase for the option "In field trips (zoo/aquariums/etc)" in the post-test could be attributed to the fact that most classes in this study, between the pre and post-test dates, held field trips to the Vasco da Gama Aquarium, which left very positive impressions on the students and possibly influenced the results, emphasizing the positive effect these direct experiences have on the interest of younger generations.

The level of awareness seemed to be positively influenced by the activity, especially concerning "ocean literacy" and "marine biodiversity". This is understandable, as the main theme of the activity was marine biodiversity, and as OL was a relatively new concept for the students, having been explained several times during the activity. Habitat destruction and marine pollution, having the highest awareness scores, is in line with Mogias *et al.* (2019), which states the higher levels of awareness associated with these ocean themes.

The activity also seemed to have a positive effect on students' daily attitudes, observing an increase for sustainable actions and a decrease for the non-sustainable ones. The potential for behavioural change in such educational programmes has also been highlighted in previous studies (Ballantyne *et al.*, 2001). However, the questions relating to students' communication, concern and confidence in individual action suffered a slight decrease, although the scores remained relatively high. This conflicting result between daily attitudes and other OL dimensions are consistent with the findings of other studies, in which it is stated that the general public, despite showing positive attitudes toward behavioural change, has little

trust in their individual behaviour (Belden Russonello & Stuart, 1999; Gelcich *et al.*, 2014; Lucrezi *et al.*, 2022).

All the classes present in this study were enrolled in the Escola Azul programme, having more exposure to marine science education and related activities, as well as teachers who are invested in teaching about these topics. This could have made students more aware, knowledgeable and interested in learning about ocean themes, which in turn may have had a positive effect on the results of the study, emphasizing the importance of such activities for a student's development as an ocean literate citizen.

Students seemed to enjoy learning about marine biodiversity, especially fish and marine mammals, showing interest in learning even more about them in future activities. While learning, people tend to gravitate towards topics they're already interested in (Falk & Storksdieck, 2009), so this particular interest in learning more about these groups is consistent with this notion, considering young students' captivation with animal life (Marrero, 2010; Guest *et al.*, 2015) and the focus given to them in school, particularly marine mammals and fish (Costa *et al.*, 2021). In the face of this reality, it's important for marine education programmes to use these more charismatic animal groups to create interest in other marine species and ocean topics (Guest *et al.*, 2015), as well using educational approaches that inspire positive feelings towards the ocean and create a sense of responsibility in its conservation, as knowledge alone isn't enough to improve behaviour towards the ocean (Johnson & Činčera, 2015; Stoll-Kleemann *et al.*, 2019; Pirchio *et al.*, 2021).

Finally, many students sought advice in how to adopt more environmentally friendly, precautionary attitudes in their daily lives, showing active interest in wanting to improve their individual action. With the immediate and long-term threat of climate change and the media coverage of said issue, many young people feel anxiety about the state of the environment, feeling hopelessness about their individual impact on the world (Léger-Goodes *et al.* 2022), as seen in question 5. Therefore, it is important to inform and empower students with a better knowledge of what they can improve in their daily lives to help the environment, offering clear guidelines beyond what they've perhaps already heard (recycling, avoiding waste, etc.). These steps could lead to students being better prepared as environmentally responsible citizens, as well as becoming agents of behavioral change for their peers and family.

5.2 Teachers

Teachers had a clear preference for activities related to ocean pollution, marine biodiversity and sharks. This is consistent with previous studies that mention the higher relevance held by ocean pollution and marine biodiversity (Mogias *et al.*, 2019) in the general public, and teachers, consequently. Sharks are, in general, a charismatic group of animals with high visibility and associated curiosity (Albert *et al.*, 2018), so it was expected that they would be a popular choice for MVE activities. This could have been heightened by the shark activity having been a brand new one, where the novelty may have played a role in its success. Hands-on and outdoor activities were also some of the most popular among those planned in the MVE programme. This is an encouraging finding, given the impact these types of activities have on students' awareness and personal connection to the environment around them and the consequent ability to promote environmentally responsible behavior (Vaske & Kobrin, 2001; Poudel *et al.*, 2005; Kelly *et al.*, 2021).

According to the teachers, the MVE activities presented in their classes positively changed the students' interests, knowledge and attitudes, but their attitudes less so. This is consistent with the results obtained in questions 3, 4, 5 and 6 of the students' questionnaire, in which attitudes were less positively affected by the activities than their knowledge and interests. Moreover, these EE activities not only have a positive impact on students but can also provide teachers with new interests and knowledge on various marine topics (Aurélio *et al.*, 2022). In the questionnaire, there seems to have been a consensus among teachers that the activities created an interest in developing OL activities autonomously. By providing teachers with new knowledge of marine (environmental) topics through EE activities, they will be inspired to implement new approaches for OL in the classroom (Poudel *et al.*, 2005; Laursen *et al.*, 2007).

Many teachers discovered the MVE activities by recommendation of another colleague or via social media. Social media is increasingly prevalent for the spread of information in today's world, being an important tool for many entities to spread information about their projects (Tobey *et al.*, 2014). As per the results obtained in this study, it is encouraged that EE entities take social media as an outreach method to promote themselves and the activities they develop. This is especially important, considering many Portuguese teachers may not know where to find existing marine science education entities (Freitas *et al.*, 2022).

Teachers in this study seemed to be satisfied with the way ocean themes are currently implemented in the Portuguese curriculum. This is contradictory with the findings of other studies, in which teachers of various countries, including Portugal, mentioned the current curriculum not adequately addressing ocean science, being an obstacle in the improvement of OL in school settings (Aurélio *et al.*, 2022; Freitas *et al.*, 2022). The current Portuguese curriculum does implement ocean topics between the 1st and 8th grade. However, it does so minimally, never touching upon OL in an explicit manner, as well as having a much bigger focus on terrestrial environment and terrestrial living beings when addressing the environment across different subjects. This lack of OL topics in the curriculum is especially apparent from 8th grade onwards, with no mention of the ocean from that grade onwards (DGE, n.d.-a). The subject of citizenship education, despite being a useful avenue for addressing OL through the domain of EE, is also limited in this regard, given that only a limited number of optional domains can be addressed per school year, and considering the many other domains eligible to be explored within the subject, the likelihood of the EE domain not being selected is high.

Teachers claimed frequently approaching ocean themes in their classes, as well as expressing high confidence in doing so autonomously. This is inconsistent with the results in question 9 and 11, which point to most teachers having average to below average awareness of the 16 terms associated with OL,

as well as having a clear preference for teaching well known terms within society, such as sustainability, marine pollution and climate change, or themes already present in the curriculum, such as the water cycle. The teachers' supposed frequency and confidence in teaching ocean themes autonomously is also in conflict with the results obtained in question 12 and 13, in which it was evident that teachers held a preference for teaching ocean-related subjects in collaboration with researchers, undertaking field trips or employing alternative pedagogical methodologies, rather than on their own, as was the case when teaching non-ocean-related themes, revealing a dependence/reliance in external entities when it comes to teaching marine science. These conflicting results could be explained by the teacher's average knowledge of ocean science (Mogias *et al.*, 2015; Hartley *et al.*, 2018), having limited understanding of its issues (Eddy, 2014). Because of this limited knowledge, teachers may have incorrect notions of what might be presently missing in the school curricula in terms of OL. Furthermore, a dense curriculum may dissuade educators from incorporating additional subjects into their classrooms, since they may already feel overwhelmed by the existing curriculum, and thus unable to accommodate marine issues alongside the existing subject matter.

Teachers in this study urged for specialized training directed at improving their OL knowledge in and their application of said knowledge in class as crucial steps in improving marine science in school settings. This goes in line with previous studies, which mention the teacher's knowledge of marine environment as one of the main incentives for including marine science in a school context (Mogias *et al.*, 2015; Freitas *et al.*, 2022). Additionally, they mentioned digital resources as an important tool for improving their capability to instruct their students in these themes, as well as expressing their need for more expert and peer support alike. These findings were consistent with those of previous research, which identified a crowded curriculum, inadequate knowledge and awareness of the marine environment, and the lack of accessible OL educational resources as the main challenges to integrating it into the Portuguese curriculum (Fauville *et al.*, 2018b; OECD, 2018; IOC-UNESCO, 2022).

This study has highlighted, in both students and teachers, the positive effect OL activities have on their awareness, knowledge, behaviour and interests concerning these topics. Therefore, EE entities should be encouraged to further implement and promote such activities. However, the reach of these activities by themselves has its own limits, considering their sporadic nature. It is necessary for teachers to feel more confident and independent in teaching these topics, given that by having constant contact with the students, the teachings they provide may have greater staying power than isolated EE activities (Pirchio *et al.*, 2021). To this end, it is necessary to support teachers with specialized training that can provide them with knowledge about ocean themes and how to approach them in class, as has been done by institutions such as Oceanário de Lisboa, MVE or OOM (Observatório Oceânico da Madeira), which all offer both activities for students and specialized training for teachers (Costa & Caldeira, 2021; O MARE vai à escola, n.d.; Oceanário de Lisboa, n.d.). Nevertheless, improving the OL level in schools is not solely the responsibility of environmental educators, and it is crucial for the Portuguese curriculum to be updated in the future, in order to have a more cross-curricular approach of the ocean and to give due relevance to marine science. An additional approach to this issue would be to include OL as a mandatory domain within the citizenship education subject, as proposed in IOC-UNESCO (2022).

Portugal is one of the countries with the most profound connection with the marine environment, having the largest EEZ in the EU and the 10th largest EEZ in the world (Calado *et al.*, 2024). With most of the population living in coastal areas, Portugal must strengthen its commitment to the appreciation of the sea. It is our hope that, by following the recommendations of this study, Portuguese teachers can become more ocean-literate citizens, and consequently better educators for Portuguese students, bringing Portugal closer to being aligned with the UN's SDGs.

5.3 Answers to the research questions

1. What topics are most addressed in the context of ocean literacy in schools?

This study aimed at understanding which topics were most commonly chosen by teachers when addressing OL in schools, and so teachers who had previously requested for MVE activities were inquired as to what activities they had sought in the 2022/2023 school year. The most addressed topics in the context of OL in schools were related to ocean pollution, marine biodiversity, with a particular interest in charismatic species, such as sharks. Additionally, hands-on and outdoor activities, irrespective of the topic addressed, seem to be a popular choice in school contexts.

2. What motivates the choice of ocean literacy topics in schools?

Besides knowing which OL topics were preferred by teachers, this study wanted to understand the motives behind these preferences. According to the results of this study, the choice of OL topics in Portuguese schools seemed to be motivated by a need to increase the knowledge of the students, as well as the development of their citizenship skills. The recency and topicality of the theme in society also seemed to be a big motivator in the choice of said theme. Finally, the direct interaction of researchers with students seemed to be a major motivator in choosing OL activities.

3. What kind of teaching methodologies do schools use to address ocean literacy issues?

One of the main goals of this study was to characterize the main pedagogic methodologies used by teachers when addressing marine issues, thus teachers were asked what approaches were most used when addressing OL, as well as when addressing non-OL topics, in order to compare both. Teachers mentioned researcher-led activities, field trips, teacher-led learning, outdoor exploration activities and autonomous student learning as the main pedagogic methodologies used when approaching the former. This diverse use of methodologies is in contrast to how teachers address the latter, where teacher-led learning was the predominant pedagogic approach.

4. What gaps do teachers feel there are in addressing ocean literacy issues in the school context?

This study aimed to understand what gaps might exist in the way ocean literacy is addressed in schools. To do so, the teachers were questioned about what improvements could be made to help them better implement ocean literacy in their classes. Teachers stated their need for more specialized teacher training in the improvement of knowledge of marine issues, as well as how to approach these issues to their students in order to better address OL. Teachers also urged for more expert/researcher support, as well as better peer support in field trips. Finally, the creation of digital classroom tools was listed as a necessary direction in improving the inclusion of ocean-related themes in a school setting. These results appear to be consistent with previous research, which mentions the crowded Portuguese curriculum, a lack of knowledge and awareness of marine environments, and minimal educational resources as some of the main reasons for the inadequate inclusion of OL in the Portuguese curriculum.

5. What knowledge do elementary school students have regarding the topics covered in ocean literacy?

The goal of this research question was to measure the level of OL knowledge amongst elementary students, and so the knowledge section of the pre-test questionnaire, with 10 questions related to the main objectives of the educational activity, was applied to the students before said activity was presented. The elementary school students in this study revealed a moderate level of knowledge regarding OL topics, scoring an average grade of 6,175 out of 10 in the knowledge section of the pre-

test questionnaire, with the questions ranging from 30% of correct answers to 96%. Moderate levels of OL knowledge were also present in previous research from other countries.

6. Do ocean literacy activities in a school context succeed in promoting knowledge of these themes in elementary school students?

This question aimed at understanding the extent to which an OL activity changed the knowledge of elementary school students. To this end, the results of the knowledge section of the pre and post-test questionnaire were measured and compared. The activity lectured in this study succeeded in promoting knowledge of the associated themes in elementary school students, as it was possible to observe an increase in the average grade of the knowledge section between the pre and post-test of the questionnaire, from 6,175 to 7,383 points out of 10, with every question except one being subject to increases in the post-test. These findings align with those of existing research.

5.4 Closing remarks

The aim of this dissertation was to understand whether OL is being approached in Portuguese schools in a way that educates and empowers the next generation and how the current approach could be improved in the future. Additionally, it set out to understand whether activities in schools have a positive impact on the knowledge of primary school children.

A positive effect was found in students' awareness and knowledge following OL activities, which seemed to extend to their teachers who were generally inspired to teach these topics. Thus, environmental educators are encouraged to implement and further promote marine science activities in the future. Nevertheless, in the future, environmental educators could try to implement activities that 1) use the popularity of the most well-known species or topics to address lesser-known ones; 2) focus on educating students about concrete ecologically friendly behaviours they could adopt on a daily basis, in order to empower them and increase their confidence in their individual behaviour. Additionally, considering the teachers' recommendations expressed in this study, it is suggested for environmental educators to expand from teaching activities aimed at students to also create specialized training for teachers, as teachers currently seem to lack ocean literacy knowledge besides popular topics within society, as well as how to approach said topics in the classroom independently. Such training is necessary so that teachers are not dependent on activities carried out by others.

Given the ocean's historical significance to Portugal and its continued relevance in the daily lives of its people, the Portuguese government has a responsibility of enhancing the current level of marine science education in its schools. Further inclusion of marine science into the Portuguese curriculum, as well as making such themes a mandatory requirement in the citizenship education subject, are steps the government should be encouraged to pursue as to improve ocean science in Portuguese schools.

OL aims to foster the development of individuals who are able to 1) comprehend ocean-related concepts and their significance; 2) communicate about the ocean in a meaningful manner; 3) make informed and responsible decisions about the environment and its resources. There is hope that, by improving teacher's knowledge, pedagogic resource and curriculum support, they will become more independent in teaching these subjects. This, coupled with the efforts of environmental educators, can facilitate the development of future generations of ocean-literate citizens, thus advancing Portugal's commitment to the UN's SDGs.

The classes selected for this dissertation were chosen based on their affiliation to the Blue School programme, all belonging to the Barreiro municipality. It would be beneficial for future studies to consider comparing schools from different regions, as it could help elucidate whether proximity to the sea or marine environments has an influence on Portuguese teachers' and students' OL knowledge, which has been addressed in previous studies, but also on the way OL topics are approached by teachers in their lessons. These studies could also explore the impact of other factors, such as the type of educational institution (private or public) or socio-economic context, on the way in which these topics are addressed.

The teachers who participated in this study were mainly elementary and middle school teachers. Considering the lack of marine science curriculum beyond the 8th grade, it could be of interest for future studies to understand high school teachers' approach to marine science, especially given the existence of national exams in the 11th and 12th grades, which increase the pressure to fulfil the curriculum.

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List of annexes

Annex 1 – Student's questionnaire

Post-test

The Ocean is a Big Home

Write: Your birth day and month and the first letter of your name (**for example: 23/08 M**)

_____

Gender: Male ___ Female ___ School Year: 3rd grade ____ 4th grade ____

Age: _____

I – Habits and perspectives

For each of the questions, fill in the correct option **with an "X".**

1. Why do you like the ocean? (check all the options you agree with)

	Because I can swim/go to the beach
	Because I like animals
	Because it gives me food
	Because it's important for life on Earth
	Because it's beautiful
	I don't like the ocean
	Other (which?): _____

2. Until today, I've learned more about the ocean... (check **two options**):

	In class
	On the internet
	Reading books at home
	With my family
	Watching TV

	Playing videogames
	In field trips (zoo/aquariums/etc)
	When I go to a beach/river/lake
	Other (which?): _____

For each of the sentences, select the option that makes the most sense to you.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
3. I care about people's impact on the ocean.					
4. I talk to my friends or family about how to reduce our impact on the ocean.					
5. I believe I can help the ocean with more environmentally friendly attitudes.					

6. From the options below, which do you usually put into practice with your family? (select **all the options** you put into practice)

	I recycle
	I take long showers frequently
	I pick up garbage on the beach
	I leave the water running when I brush my teeth
	I buy plastic bags when shopping in supermarkets
	I turn off the lights when I leave the rooms in my house
	Other: _____

7. Have you heard of:

	Yes	No
Ocean literacy		
Ocean conservation		
Ocean pollution		
Climate change		
Overfishing		
Habitat destruction		
Marine biodiversity		

II – Knowledge

For each of the questions, fill in the correct option with an "X".
*Choose **only one** answer for each question. If you don't know the answer, put "I don't know".*

8. The Earth is called the Blue Planet because:

	The continents reflect the light of the sky
	The oceans are blue
	The Earth has a blue sky
	Because 70% of it is made up of water
	I don’t know

9. Which of the following is not a living being?

	Tree
	Dolphin
	Water
	Jellyfish
	I don’t know

10. Who breathes underwater?

- [ ] Reptiles
- [ ] Fish
- [ ] Mammals
- [ ] Birds
- [ ] I don’t know

11. What is the difference between reptiles and amphibians?

- [ ] Reptiles are green and amphibians are not
- [ ] Reptiles have scales and amphibians don't
- [ ] Reptiles have teeth, unlike amphibians
- [ ] Amphibians don't have tails and reptiles do
- [ ] I don’t know

12. Which of these groups of animals don't lay eggs?

- [ ] Birds
- [ ] Reptiles
- [ ] Fish
- [ ] Mammals
- [ ] I don’t know

	True	False	I don’t know
13. Invertebrates have bones, unlike vertebrates, which have no bones.			
14. The oceans are all different, but they’re all connected.			
15. To keep themselves warm, marine mammals can have a layer of fur or fat.			
16. In the ocean there are living beings, very important to us, so small they can’t be seen.			
17. All marine animals search for food in the same way.			

III – Appreciation

18. Did you like this activity?

I didn’t like it at all	I didn’t like it very much	I liked it	I liked it a lot	I loved it

19. What did you like most about the activity?

_____

20. What did you like less in the activity?

_____

21. What topics related to the ocean would you like to see presented in activities at your school?

_____

Annex 2 – Teacher's questionnaire

Diving into the ocean literacy paradigm in schools: themes, approaches and impacts

This questionnaire is part of the dissertation "Diving into the ocean literacy paradigm in schools: themes, approaches and impacts", carried out by Sérgio Reis, a master's student in Marine Ecology at the Faculty of Sciences of the University of Lisbon.

The aim of the dissertation is to find out how ocean literacy, as a tool for training and empowering future generations, is perceived and approached in schools. It also aims to provide a general characterization of the pedagogical methodologies used by teachers to approach ocean literacy themes in a school context.

Your response is anonymous and the results obtained will only be integrated and processed in an academic and scientific context. Your participation in this questionnaire is essential to the completion of this thesis.

Thank you for your cooperation!

If you have any questions, please contact fc52560@alunos.fc.ul.pt

State your gender.

☐	Male
☐	Female
☐	Other
☐	Prefer not to say

State your age.

☐	18-29
☐	30-39
☐	40-49
☐	50-59
☐	60+

Select the last degree you completed.

	Bachelor's
	Master's
	PhD
	Other

Which grade levels do you currently teach?

	Pre-school
	Elementary school
	Middle school (5^{th} and 6^{th} grade)
	Middle school (7^{th}, 8^{th} or 9^{th} grade)
	High school
	Other:

Indicate your subject group code.

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“MARE vai à escola” activity

1. Which activities proposed by "MARE vai à escola" (MVE) have you chosen to be carried out in your class this school year?

	A viagem da enguia maresia (Pre school)
	Em busca dos segredos do mar (Pre school)
	Tubarões à vista (Pre school, Elementary school)
	MARE de histórias (Pre school, Elementary school)
	As incríveis viagens dos animais marinhos (Elementary school, Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade))
	A era do lixo marinho (Elementary school, Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade), High school)
	Biólogo por um dia (Elementary school, Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade), High school)
	O MARE vai à praia (Elementary school, Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade), High school)
	A escola vem ao MARE (Elementary school, Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade), High school)
	O oceano é uma grande casa (Elementary school, Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade))
	Quem tramou o clima? (Elementary school, Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade), High school)
	Palavra de cientista (Elementary school, Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade), High school)
	Teias tróficas: energia em movimento (Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade))
	Da sobrepesca à sustentabilidade (Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade), High school)
	Espécies exóticas: aliadas ou invasoras? (Middle school (5th and 6th grade), Middle school (7th, 8th and 9th grade), High school)
	Biotec: um mar de ideias (High school)

2. Please indicate the degree of importance of the following options in your choice of activities.

	No Importance	Little importance	Some importance	High importance	Extreme importance
Suitability for the curriculum					
Current theme					
Increase of knowledge of the class					
Development of citizenship skills					
Direct interaction with researchers					
Non-formal activity					
Freeing up the teacher for other activities					

3. Evaluate the impact of this activity on your students, in terms of their interest, knowledge and attitudes towards the subject.

	Very negative	Negative	Unaltered	Positive	Very positive
Interest					
Knowledge					
Attitudes					

4. How did you find out about these activities/this project?

	Social media
	Mailing list
	Newspapers
	Recommendation of another colleague
	Through another environmental education entity
	Other:

5. To what extent did the "MARE vai à escola" activities spark an interest in developing autonomous ocean literacy activities with your class?

No interest	Little interest	Some interest	Considerable interest	Very high interest

6. Have you ever carried out ocean literacy activities with organizations other than "MARE vai à escola"? If so, which ones?

_____

<u>Ocean literacy in a school context</u>

7. How often do you teach ocean-related subjects at school?

Never	Rarely	Sometimes	Frequently	Almost always

8. How would you define ocean literacy?

	Understanding the importance of ocean health in marine ecosystems
	Studying the effect of climate change on the ocean and marine ecosystems
	Understanding the ocean's influence on us and our influence on the ocean
	Understanding of good economic practices linked to the ocean

9. Indicate which of the following topics you can define.

	Climate change
	Ocean conservation
	Sustainability
	Ocean pollution
	Ocean warming
	Ocean acidification
	Ocean deoxygenation
	Ocean interconnectivity
	Marine migrations
	Trophic webs
	Water cycle
	Marine biodiversity
	Exotic species
	Overfishing
	Biomimicry
	Blue biotechnology

10. How would you describe your level of confidence in carrying out ocean-related activities on your own?

No confidence	Little confidence	Some confidence	High confidence	Extreme confidence

11. Indicate which marine science topics you have taught in your classes.

	Climate change
	Ocean conservation
	Sustainability

	Ocean pollution
	Ocean warming
	Ocean acidification
	Ocean deoxygenation
	Ocean interconnectivity
	Marine migrations
	Trophic webs
	Water cycle
	Marine biodiversity
	Exotic species
	Overfishing
	Biomimicry
	Blue biotechnology

12. Please choose the teaching method you use most in school, in general.

	Teacher-led learning (oral presentation, slide projection, textbook reading and exercises)
	Researcher/expert-led learning (lectures or activities)
	Students' autonomous inquiry learning in class
	Outdoor activities (recreation, community, nature)
	Field trips to a zoo/aquarium/other similar institutions
	Hands-on/Experimental activities
	Debates and other critical thinking activities
	Simulation/role-playing activities
	Digital learning activities
	Game based learning
	Other:

13. Please indicate the teaching method you use most often to teach about the ocean.

	Teacher-led learning (oral presentation, slide projection, textbook reading and exercises)
	Researcher/expert-led learning (lectures or activities)
	Students' autonomous inquiry learning in class
	Outdoor activities (recreation, community, nature)
	Field trips to a zoo/aquarium/other similar institutions
	Hands-on/Experimental activities
	Debates and other critical thinking activities
	Simulation/role-playing activities
	Digital learning activities
	Game based learning
	Other:

14. Please rate your level of satisfaction regarding the inclusion of ocean-related topics in the school curriculum.

No satisfaction	Low satisfaction	Some satisfaction	High satisfaction	Very high satisfaction

15. From the list below, indicate the support tools that would improve your ability to include ocean-related themes in your class.

	Specialized training aimed at improving teachers' knowledge of ocean subjects
	Improved knowledge of pedagogic approaches for ocean-related themes
	Improvement of classroom infrastructure
	Creation of digital classroom tools
	Bigger support by experts/researchers
	Better peer support in field trips
	I'm already comfortable with my current marine science teaching practices

☐ Other:

16. Which ocean-related themes are not part of the Portuguese curriculum, but that you think are important to be covered?

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