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Long-term educational intervention to promote ocean literacy

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ABSTRACT

The ocean plays a critical role in sustaining society and global biodiversity. However, a range of environmental impacts has led to its degradation. In response, initiatives promoting the sustainable use of marine environments, such as educational programs on ocean literacy, have gained importance. Despite these efforts, the short duration of many interventions has limited their ability to address the diverse relationships that social groups have with the ocean. This limitation often excludes marginalized segments, such as students experiencing school retention. One proposed solution to engage these groups is the integration of the ten dimensions of ocean literacy into educational interventions. This study describes the design, implementation, and evaluation of a long-term educational intervention comprising 30 sessions with students in situation of school retention from a public school in Rio de Janeiro, Brazil. The findings revealed that while students initially resisted engaging with the knowledge dimension, this resistance was not insurmountable. By aligning the principles and concepts of ocean literacy with the students' realities and incorporating the other nine dimensions of ocean literacy, knowledge acquisition was facilitated. These results are particularly relevant for educational interventions that aim to work holistically with the ten dimensions of ocean literacy, emphasizing the adaptation of global issues to local contexts as a strategy to engage students resistant to formal schooling.

1. Introduction

The ocean is fundamental in sustaining society by providing food, energy sources, and job opportunities (Santoro et al., 2017). Additionally, the marine environment contributes to critical biogeochemical cycles, such as water, nitrogen, and phosphorus, and helps maintain climate stability-processes essential for supporting global biodiversity (Chalkiadakis et al., 2022). Despite its' importance, the ocean is experiencing significant degradation due to environmental impacts. For instance, ocean surface temperature has been reaching dramatic increases since the 1970s. While in the period between 1850 and 1900 the average ocean surface temperature increase was 0.8 °C, in the last 50 years (1970–2020) it was recorded 1.3 °C, a direct consequence of the release of large amounts of greenhouse gases into the atmosphere. High ocean water temperatures have caused impacts such as rising sea levels, intensified ocean acidification and increased heat waves (Intergovernmental Panel on Climate Change, 2023). Other contributing factors include the collapse of fish stocks caused by overfishing, and the accumulation of organic and synthetic waste, which generates anoxic zones and microplastic pollution (Clausen and Clark, 2005; Duffy, 2021). In response to this critical situation, initiatives across various fields have proposed actions to address the degraded state of the ocean. Among these, educational initiatives promoting ocean literacy have gained prominence.

Ocean literacy is a movement that originated in the United States in 2004, positing that ocean degradation stems from a lack of public knowledge about the impact of human actions on the marine environment (Pazoto et al., 2023a). This knowledge gap, in turn, has been linked to the limited presence of ocean-related topics in formal education curricula evidenced in different countries around the world (Costa et al., 2024; Gough, 2017; O'Brien et al., 2023; Pazoto et al., 2021; Schoedinger et al., 2010). Ocean literacy was subsequently defined as "the understanding of the ocean's influence on humans and their influence on the ocean" (Schoedinger et al., 2006). This literacy is intended to be incorporated into education through the seven principles and 45 concepts established by ocean literacy (National Oceanic and Atmospheric Administration, 2020). However, more recently some researcher pointed out that ocean literacy was more than knowledge and was related also to previous social, cultural and emotional links to the ocean (Schio and Reis, 2024; Stoll-Kleemann, 2019). McKinley et al. (2023)

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based on this defined nine dimensions beyond knowledge/information which should be addressed in ocean literacy interventions in order to promote a sustainable behavior. They were perception, attitude, behavior, activism, communication, emotional connections access and experience, adaptative capacity and trust and transparency. Educational interventions addressing all or part of these ten dimensions would be able to surpass limitations and failures discussed for previous ocean literacy interventions. Furthermore, the ten dimensions would also recognized and incorporate experiences related with the marine environment which are part of the history of individuals and communities (Fox et al., 2021; Worm et al., 2021). This broader framework aims to inspire collective action for the sustainable use of the ocean and its resources across various social strata for what implementation of educational interventions to promote ocean literacy is a key strategy (Shellock et al., 2024).

Educational interventions involving the marine environment in formal education have targeted diverse audiences (Bettencourt et al., 2023; Boaventura et al., 2021). For instance, Pazoto et al. (2023b) have done an ocean literacy intervention with 235 students (ages 8–15 yrs) stimulating positive connections with the ocean in the city of Niteroi (Rio de Janeiro, Brazil). For doing so they used as educational resources cultural and natural heritage. In a different way Freitas et al. (2025) choose to work with 13 teachers in a training course in the Southern Great Barrier Reef (Australia). Beyond identifying the target audience, the scope of these interventions is a critical factor. Short-term programs often limit the variety of teaching strategies employed and may not effectively develop criticism for students' regarding the ocean's degraded state (Bettencourt et al., 2023). This issue is particularly significant when addressing educational segments that have historically been overlooked in ocean literacy initiatives, such as students in situation of school retention.

Students in situation of school retention are those whose age does not align with the grade level they attend, a phenomenon observed in countries such as Switzerland, Chile, Luxembourg, and Colombia, where the proportion of students in situation of school retention exceeds 15 % (Goos et al., 2021). In Brazil, while this percentage has declined, 13.3 % of students remain held back (United Nations Agency for Children, 2024). According to Paulo Freire (1921–1997), this disparity can be attributed to the formal education system's "banking" approach, where students' realities are disregarded in educational practices. Consequently, students become alienated from an educational system that fails to address the challenges they face in their daily lives (Freire, 2000). This disconnect often results in active resistance toward the school environment and the knowledge it delivers, which students perceive as irrelevant to their lived experiences (Savegnago and Castro, 2020).

Given the panorama of students in situation of school retention in educational systems worldwide, it's surprising that they haven't been included in discussions about ocean literacy yet, as demonstrated by a bibliographic survey in *Web of Science* that retrieved no articles concerning ocean literacy educational interventions with this student demographic, revealing a notable gap in the researches done in the field until now. To address this gap and promote ocean literacy, this study involved the design, implementation, and evaluation of a long-term educational intervention spanning 30 meetings over a school year. The program was conducted with three classes of students in situation of school retention at a public school in Rio de Janeiro, Brazil. This initiative aimed to contribute to the teaching-learning process by fostering motivation, enhancing reading, and writing skills, encouraging argumentation and creativity, and promoting citizenship. The intervention is part of the broader project *Onda Cultural* (website: https://ondaculturalnaescola.com.br/), which seeks to bridge the gap between universities and society.

The research questions guiding this study were: (1) Did the program of activities developed during the educational intervention lead to a change in students' perspectives on the marine environment? (2) Did the ocean literacy educational intervention influence students' relationship with the teaching-learning process? (3) How did the participating students and teachers evaluate the intervention? To address these questions, a mixed-methods approach was employed, incorporating both quantitative and qualitative analyses to infer the mobilization of ocean literacy dimensions (Brennan et al., 2019; Stoll-Kleemann, 2019). Data were collected using various instruments, including questionnaires, interviews, document analysis, and field notebooks.

2. Methods

2.1. Participants

During the initial engagement with the school, two meetings were held with 47 teachers to present the intervention proposal and introduce the project team. During the meetings, the teachers decided that the educational intervention would be carried out with the three classes in a situation of school retention, as they were composed of students who face greater difficulties with formal education and, therefore, the activities carried out could act as a motivating factor to stimulate their participation and interest in the school environment. Thus, two math teachers, a science teacher, an English teacher and a technology teacher ($N = 5$) who taught to the retention classes joined the proposal to include ocean literacy activities in their classes. To this end, planning meetings were held in which the content and classes in which the ocean literacy intervention would occur throughout the school year (March–November/2023) were defined and they happened independently in the three classes.

The educational intervention was conducted with these three classes which comprised 46 students (17 students in class 4A, 14 students in class 4B and 15 students in class 4C) held back at 9th grade (last year of elementary school) which means a school level below their age group (students of 14 to 17 years old are supposed to be already enrolled in the secondary school). Therefore, all of them were students in situation of school retention. Another important decision making element was that elementary school students (12–15 years old) have been recognized as influential opinion-makers (Ashley et al., 2019), therefore, they are expected to function as agents of change, shaping perspectives, opinions, and worldviews not only among their school peers but also within their families (Bettencourt et al., 2023).

Students attended a public school serving individuals aged 11 to 16, located in Niteroi, a municipality in a Brazilian coastal state (Rio de Janeiro). The school predominantly serves a population from peripheral neighborhoods characterized by low-income working families who face challenges such as housing in high-risk areas, food insecurity, and precarious employment (Cinner et al., 2022; Gould and Lewis, 2021). Parents or guardians provided written informed consent for participation in the intervention. The study was approved by the Research Ethics Committee of the Universidade Federal Fluminense (process number 4,899,994).

2.2. Intervention

The educational intervention was informed by the prior experience of the *Onda Cultural* project in 2022 (Pazoto et al., 2023b) and was designed in alignment with the principles and concepts of ocean literacy (National Oceanic and Atmospheric Administration, 2020), and dimensions of ocean literacy (McKinley et al., 2023). Six thematic axes were established to guide the intervention. These axes were chosen based on discussions meetings with the school teachers who defined what were the themes in line with the curricula, their subjects and children difficulties: 1- Natural and cultural heritage of the city of Niteroi; 2- Marine biodiversity; 3- Contributions of the ocean to society; 4- Historical aspects of the society-ocean relationship; 5- Environmental impacts on the ocean and their underlying causes; and 6- Ecological characteristics of the ocean (Fig. 1). Based on these thematic axes, 30 activities were developed utilizing diverse teaching strategies, including

Fig. 1. A – Natural and cultural heritage (Activity 3); B – Marine biodiversity (Activity 7); C – Fish morphology (Activity 10); D – What is a shell mound? (Activity 11); E – Ocean acidification, part I (Activity 12); F – Ocean acidification, part II (Activity 13); G – Educational game *Guanabara Bay through time* (Activity 16); H – Litter in natural environments, part II (Activity 17); I – First field trip (Activity 19); J – Mock jury (Activity 21); K – Third field trip (Activity 23); and L – Fourth field trip (Activity 24).

dialogical classes, seminars, field trips, laboratory lessons, educational games, and film clubs. Fig. 1 provides a panel of photos displaying some of the activities included in the educational intervention described. The intervention was implemented on a weekly basis (30 weeks) throughout the 2023 school year spanning from March to November. Fig. 2 presents an info graph which shows the integration between principles and dimensions given by the axes defined and Table 1 presents a summary of the activities, highlighting the teaching strategies employed, the principles, concepts, and dimensions of ocean literacy integrated into the intervention, as well as the time used for each of them.

As an example to illustrate how principles and dimensions were coupled in the intervention let describe the process entailed in activity 7 which was dedicated to characterize living beings from coastal and marine environments. The task involved the dimension of knowledge, more specifically related to concept C ("Most of the major groups that exist on Earth are found exclusively in the ocean, and the diversity of the major groups of organisms is much greater in the ocean than on Earth") of the fifth principle of ocean literacy what was done in the form of a laboratory practice in which students handled specimens of marine organisms. It was also considered that the dimension of emotional connections was being mobilized, especially through the students' contact with organisms considered charismatic, such as seahorses, sharks, and squid. In the same way the dimension of access and experience was mobilized since in day by day the species worked would not be seen or experienced by the students. This and all other activities were carried out based on a script that defined the pedagogical objectives, described the procedures involved in its implementation, and the principles, concepts, and dimensions of ocean literacy mobilized.

2.3. Evaluation

The educational intervention was assessed using four methods: questionnaires, interviews, document analysis, and ethnographic methods.

Questionnaires allow students to express their views independently, without the influence of peers or teachers, thereby allowing researchers to identify changes in students' ideas about a given topic (Patten, 2017). In this study, pre- ($N = 35$) and post-test ($N = 33$) questionnaires were administered, comprising 20 questions designed to outline the demographic and academic profile of the sample and assess students' knowledge of the marine environment covered during the educational intervention (Chart 2).

Interviews are a qualitative analysis method designed to produce detailed accounts of the ideas and positions of participants within a given context and can complement quantitative methods (Alshenqeeti, 2014). In this study, interviews were conducted after the educational intervention using two approaches: 1) semi-structured individual interviews conducted with a sample of the students ($N = 8$) and all partner teachers ($N = 5$), these interviews allowed participants to freely express their thoughts on predefined topics while enabling deeper exploration of specific points of interest through follow-up questions (Alshenqeeti, 2014); and 2) focus groups organized with students from the three participating classes (one for each class, 4 A-$N = 11$; 4B-$N = 9$ and 4C-$N = 8$), these sessions aimed to assess how the activities were received and

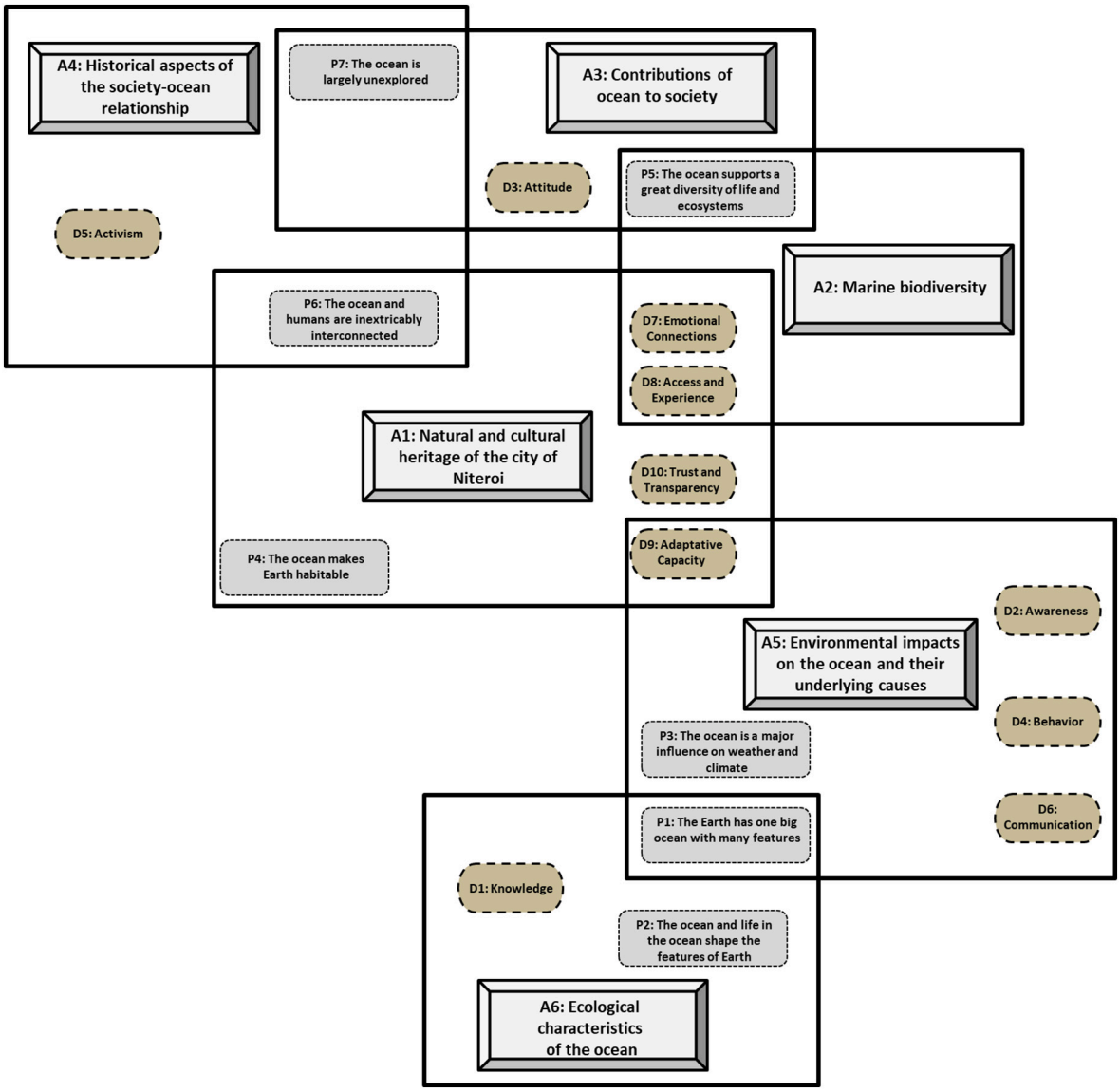

Fig. 2. Infographic showing the links between principles and dimensions of ocean literacy and the six axes that guided the educational intervention. Where: A = Axe; D = Dimension, and P = Principle.

to understand the connections students established between the intervention and their prior experiences and knowledge (Gundumogula, 2020). Chart 3 outlines the interview scripts.

Throughout the activities, students produced many documentary materials, including figures created with tangram puzzles,[1] narrative and descriptive texts, reports from laboratory experiments, and guided studies. Additionally, audio recordings were made during one activity, the mock jury. The analysis of these documentary materials (both text and audio) was used to locate, identify, organize, and evaluate information, while also contextualizing it within the moment of its production (Morgan, 2021). These materials were instrumental in tracking changes in students' ideas beyond the knowledge dimension and in assessing the impact of the educational intervention on skills such as reading, writing, argumentation, and creativity. Similarly, field notebooks were used by the activity implementers to record personal impressions, informal conversations, observed behaviors, statements, and other relevant observations. Pérez-Izaguirre et al. (2024) described field notebooks as an ethnographic tool that situates a study within a broader social and temporal context. They provide valuable insights into students' interactions, opinions, and behaviors, offering additional context for the research. The ethnographic method is characterized by participatory research and, therefore, is based on a process of immersion in the social context of the group being studied (Jones and Smith, 2017). In this sense, immersion in the school context allows the observation of students' manifestations about their values, habits, and emotions that are not usually mobilized when a response is required through questions previously prepared by the researcher, whether in the form of questionnaire questions, interview questions, or directed studies (Hammersley, 2018). Thus, the observation of students' interactions and subsequent recording in a field notebook can serve as a data collection instrument on the dimensions of ocean literacy, especially activism, adaptive capacity, emotional connections, and trust and transparency (Shellock et al., 2024). Chart 4 summarizes the methods, instruments, and evaluation goals employed in this study.

[1] Tangram is a Chinese-origin puzzle consisting of seven geometric pieces—five triangles, one square, and one parallelogram—that can be arranged to form various figures (Merriam-Webster, 2024).

Table 1
Educational intervention activities, teaching strategies utilized, the principles, concepts, and dimensions of ocean literacy addressed, and the duration of each activity (measured in hours). Ordinal numbers refers to temporal sequence of activities, cardinal numbers refers to ocean literacy principles and the letters between parentheses are related to the concepts relative to the numbered principle (For a complete description of the 45 essential concepts, please refer to National Oceanic and Atmospheric Administration, 2020).

#	Activity	Teaching strategy	Ocean literacy		Duration (hours)
			Principles (concepts)	Dimensions	
1st	Presentation to the teaching team	X	1 (A, H); 6 (F, G)	Knowledge; Awareness	0.67
2nd	Pre-test	Evaluation	1 (A, F); 2 (A, E); 3 (A, B); 5 (A, B, C); 6 (A, B, C, G); 7 (A, B)	Knowledge; Attitude; Communication; Access and Experience	0.67
3rd	Natural and cultural heritage	Directed study	1 (A, G); 4 (A, C); 5 (I); 6 (A, B, C)	Knowledge; Awareness; Access and Experience; Emotional Connections	1.33
4th	Discussion circle on ocean literacy	Seminar	2 (A); 3 (A, E); 5 (E); 6 (B)	Knowledge; Attitude; Behavior; Emotional Connections; Access and Experience	0.67
5th	Litter in natural environments – part I	Laboratory lessons; Inquiry-based learning	1 (C, G, H); 6 (D, F, G)	Knowledge; Awareness; Activism; Emotional Connections	1.33
6th	Discussion of the film *Ilha das Flores* (Furtado, 1989)	Filmclub; Simulation	6 (D, G)	Knowledge; Awareness; Activism	0.67
7th	Marine biodiversity	Laboratory lessons; Inquiry-based learning	5 (C, D, E, F)	Knowledge; Awareness; Communication; Emotional Connections; Access and Experience	1.33
8th	Coastal ecossistems	Dialogical class	1 (B, D, E, G); 2 (B, E); 5 (A, E, F, I); 6 (B); 7 (A)	Knowledge; Emotional Connections; Access and Experience	0.67
9th	Types of sediments	Laboratory lessons; Inquiry-based learning	2 (A, B, C, E); 6 (B)	Knowledge; Access and Experience	1.33
10th	Fish morphology	Laboratory lessons; Inquiry-based learning	5 (D)	Knowledge; Emotional Connections; Access and Experience	1.33
11th	What is a shell mound?	Guided reading	1 (H); 4 (A, B, C); 5 (E, F); 6 (B, C, E, F, G); 7 (C)	Knowledge; Awareness; Attitude; Communication; Adaptative Capacity	1.33
12th	Ocean acidification – part I	Laboratory lessons; Inquiry-based learning	1 (C, E, H); 2 (D); 3 (A, E, F, G); 4 (C); 6 (A, D, E)	Knowledge; Awareness; Attitude; Behavior; Activism; Adaptative Capacity	1.33
13th	Ocean acidification – part II	Laboratory lessons; Inquiry-based learning	1 (E); 2 (D); 3 (E, F, G); 6 (D, E)	Knowledge; Behavior; Activism; Adaptative Capacity	1.33
14th	Fact or fake?	Inquiry discussion groups	1 (A, B, C, G, H); 3 (E); 5 (C, E, F, H); 6 (A, B, D, E, G)	Knowledge; Awareness; Attitude; Behavior; Communication; Adaptative Capacity; Trust and Transparency	0.67
15th	Water properties	Laboratory lessons; Inquiry-based learning	1 (A, B, C, D, E)	Knowledge; Access and Experience	1.33
16th	Brainstorm and the educational game *Guanabara Bay through time*	Brainstorm; Educational game	1 (A, G); 5 (A, C); 6 (B, C, D, F); 7 (C)	Knowledge; Awareness; Attitude; Behavior; Emotional Connections; Adaptative Capacity	1.33
17th	Litter in natural environments – part II	Laboratory lessons; Inquiry-based learning	4 (C); 6 (B)	Knowledge; Awareness, Behavior	0.67
18th	Tangram	Problem solving	5 (A, C, D, E, F, G); 6 (B, C)	Knowledge; Attitude; Behavior; Communication	1.33
19th	Fieldtrip to Lagoa, Praia e Museu de Arqueologia de Itaipu	Fieldtrip; Hands-on learning	5 (E, F, I); 6 (D)	Knowledge; Awareness; Communication; Emotional Connections; Access and Experience; Trust and Transparency	4.66
20th	Discussion of the film *Entremarés* (Andrade, 2018)	Filmclub; Simulation	1 (G, H); 5 (I); 6 (B, C, D, G)	Knowledge; Awareness; Attitude; Behavior; Activism; Emotional Connections	0.67
21st	Mock jury: explore or preserve Guanabara Bay	Guided reading; Mock jury	1 (G, H); 4 (C); 5 (A, C, D, E); 6 (A, B, C, D); 7 (F)	Knowledge; Awareness; Attitude; Behavior; Activism; Communication; Trust and Transparency	1.33
22nd	Fieldtrip to Praia da Boa Viagem, Museu de Arte Contemporânea e Museu Janete Costa	Fieldtrip; Hands-on learning	5 (A, C, E, F); 6 (A, B, C, D, F)	Knowledge; Awareness; Communication; Access and Experience; Trust and Transparency	4.66
23rd	Fieldtrip to Trilha Caminhos de Darwin e Fazenda Itaocaia	Fieldtrip; Hands-on learning	4 (B); 6 (D, E, G)	Knowledge; Awareness; Attitude; Behavior; Activism; Communication; Trust and Transparency	4.66
24th	Fieldtrip to Parque da Cidade, Jurujuba e Projeto Aruanã	Fieldtrip; Hands-on learning	1 (H); 5 (D); 6 (B, C, D, G)	Knowledge; Awareness; Attitude; Behavior; Activism; Access and Experience	4.66
25th	Students' interviews	Evaluation	X	Behavior; Activism; Emotional Connections; Access and Experience; Trust and Transparency	0.67
26th	Texts about the fieldtrips	Inquiry discussion groups	5 (F, I); 6 (B, C, D)	Communication; Trust and Transparency	1.33
27th	Picture exhibition	Simulation	1 (G, H); 3 (B); 5 (C, D, I); 6 (C, D, F); 7 (A, B, C)	Awareness, Communication, Access and Experience, Trust and Transparency	2.00
28th	Post-test	Evaluation	1 (A); 2 (A, E); 3 (A); 5 (A, B, C); 6 (A, B, C, G); 7 (A, B)	Knowledge; Attitude; Communication; Access and Experience	0.67
29th	Students' focus groups	Evaluation	1 (H); 6 (E, G); 7 (C)	Knowledge; Awareness; Attitude; Behavior; Activism; Communication; Emotional Connections; Access and Experience; Adaptative Capacity; Trust and Transparency	0.67

(*continued on next page*)

Table 1 (*continued*)

#	Activity	Teaching strategy	Ocean literacy		Duration (hours)
			Principles (concepts)	Dimensions	
30th	Teachers' interviews	Evaluation	X	Access and Experience	0.67
TOTAL DURATION OF THE INTERVENTION					45.97

Chart 2
Command summary and quiz question type.

Section	Question	Type
1	1) Age	Open-ended
	2) Gender	
	3) Sources of knowledge about the marine environment	Close-ended
2	1) How often do you go to the sea/beach?	
	2) Activities you do at the sea/beach	Open-ended
	3) Importance of the ocean	Close-ended
	4) Reason why the ocean is important	
	5) Benefits obtained by society from the ocean	
3	1) Percentage of the planet's surface covered by ocean	
	2) There is a single ocean with varying characteristics	True/False
	3) Seawater salt source	Close-ended
	4) Tectonic activity, sea level changes and waves can alter coastal landscapes	True/False
	5) Source of evaporation from which most of the rain originates	Close-ended
	6) The ocean has a major influence on controlling climate and climate change	True/False
	7) Environment in which most groups of living beings are found	Close-ended
	8) Group to which most living beings found in the ocean belong	
	9) Society obtains food, medicine, minerals and energy resources from the ocean	True/False
	10) People who live far from the ocean do not cause ocean pollution	
	11) Percentage of the ocean, other than the surface, that has already been studied	Close-ended
	12) Why it's important to study the ocean	

Chart 3
Interview scripts and their respective target group.

Instrument	Target group	Structure
Semi-structured individual interview	Students	1) What differences did you notice between school classes and the activities of the *Onda Cultural* project?
		2) How did the project activities influence your relationship with the marine environment?
		3) What was your favourite activity and why?
	Teachers	1) How do you evaluate the students' participation in the project activities? Was there any difference in relation to the curricular subjects?
		2) Are activities such as laboratory lessons and field trips usually carried out in everyday school life?
		3) What obstacles do you identify in including marine environment topics in your discipline?
		4) Did you think it was possible to include marine environment topics in your course? In what way? Now, what do you think about it?
		5) Considering the fact that the project used up time from your classes, would you be willing to participate in the project next year?
		6) How do you evaluate the project activities?
Focus group	Students	1) What did you learn from the project?
		2) Before the lesson involving ocean acidification, did you already recognize acidification as an environmental impact on the ocean?
		3) What was it like to participate in a mock jury?
		4) What can be done in relation to the amount of trash ending up in the ocean?
		5) Is it enough to change individual behaviors to overcome the problem of marine litter?
		6) Would you recommend the two movies that we watched (*Ilha das Flores* and *Entremarés*)? Why?
		7) Which activity did you like the most?
		8) Have you already visited the field trip locations?
		9) What can be done in the face of a rapidly changing ocean?
		10) Are you able to identify fake news about the ocean?

2.4. Data analysis

Questionnaire responses were analyzed using descriptive statistics (*e.g.*, mean, mode, variance) and presented in graphs and charts. Furthermore, every time that relevant differences were inferred statistical tests (non parametric Mann-Whitney *U* test) was applied in order to ascertain the significance of these differences using the software *PAST 2.08* (Hammer et al., 2001).

Interview audio recordings were transcribed and subjected to textual analysis using IRAMUTEQ (*Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires*), a software that employs the R interface for multidimensional textual corpus analysis (Camargo and Justo, 2024; Ratinaud, 2009). The audio recordings generated three distinct textual *corpus*: 1) semi-structured individual interviews with students; 2) semi-structured individual interviews with teachers; and 3) focus groups with students. From these *corpus*, two analytical outputs were produced: 1) similarity networks – graphical representations indicating the connectivity between words, enabling the identification of shared content; and 2) word clouds – visual depictions of word frequencies within the textual data (Camargo and Justo, 2024).

The textual documents produced by the students were analyzed using content analysis (Bardin, 2011). This technique involved the following steps: 1) pre-analysis – a floating reading of the material to formulate hypotheses and objectives while determining the recording units; 2) coding – systematic transformation of the data into codes, which were then aggregated into units to enable an accurate description of the content's characteristics; and 3) processing of results – classification of elements based on their similarities and differences into categories. When new characteristics emerged during the analysis, regroupings were conducted to refine the categories.

The ethnographic method used field notebooks, which provided descriptions and analyses of the students' "other culture", based on participants' actions and meanings (Pérez-Izaguirre et al., 2024). Observations recorded in the field notebooks were organized into 30 activity reports, allowing for a detailed analysis of how students responded to the educational intervention and how and what dimensions of ocean literacy could possibly have been mobilized during the activities.

Chart 4
Methods, tools, target groups, and evaluation objectives.

Method	Instrument	Target group	Objectives
Questionnaire	Pre and post-test	Students	Describe the sample Determine changes in students' knowledge
Interviews	Semi-structured interview	Students	Assess students' interest in the intervention Identify preferred activities
		Teachers	Relate student attendance and interest with aspects of the activities Identify obstacles and opportunities for including marine environment topics in curricular subjects
	Focus group	Students	Examine aspects of the established discussions that were assimilated by the students
Document analysis	Activity reports Images Texts Reports Mock juries	Students	Assess the development of students' reading, writing, argumentation and creativity Monitor the changes that occurred in students' ideas throughout the activities
Ethnographic method	Field notebook	Students Teachers	Identify what principles, concepts and dimensions of ocean literacy were addressed Detail the objectives achieved by the activities Evaluate the effectiveness of the intervention in promoting ocean literacy

3. Results

3.1. Participants

The sample of students who participated in the educational intervention ($N = 35$) predominantly consisted of 15-year-olds (Fig. 3A), with a higher proportion of males than females (Fig. 3B). Regarding the sources of information students used to learn about the marine environment, the internet, school, television, and social network were the most frequently mentioned (Fig. 3C).

Most students reported visiting the sea or beach during vacations or weekends (Fig. 4A), engaging in activities such as sports (*e.g.*, playing foot volleyball and swimming), contemplation (*e.g.*, enjoying the view and sunbathing), and consumption-related activities (Fig. 4B). When asked about the importance of the ocean, 80 % of students indicated that the ocean was extremely or very important (Fig. 4C), primarily citing biological and environmental reasons (Fig. 4D). Additionally, the most frequently mentioned benefit of the marine environment was its provision of food, followed by its role as a source of energy (Fig. 4E).

3.2. Intervention

Throughout the educational intervention, all seven principles of ocean literacy were addressed, along with 41 of the 45 fundamental concepts and all ten dimensions of ocean literacy. The dimension of "knowledge" about the marine environment was mobilized through a PowerPoint presentation that included images and basic concepts about the country's main coastal ecosystems, interspersed with discussion questions (activity 8). While students remained attentive during the presentation, they initially showed little interest in the content, even

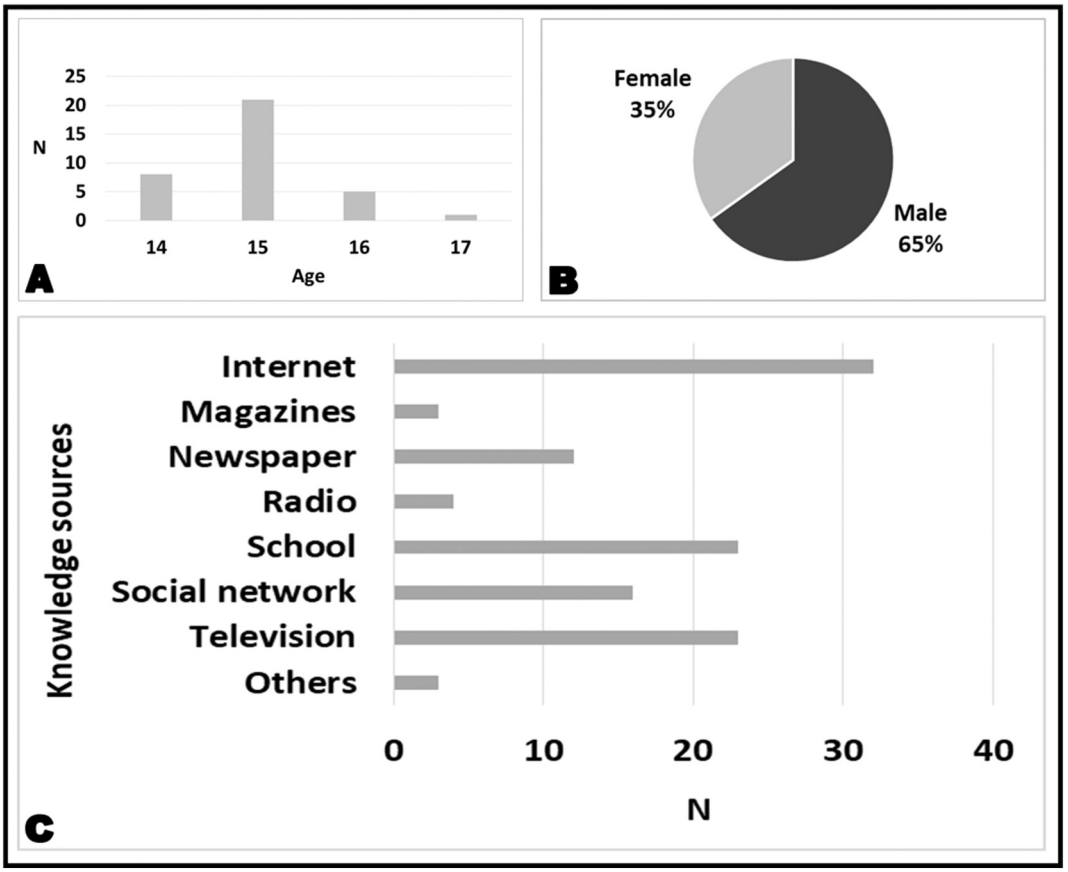

Fig. 3. Sample description in terms of age (A), gender (B), and knowledge sources regarding the ocean (C). Where: N – number of responses which in case of the Fig. 3C surpasses the total number of students as they could choose more than one alternative as answer to the question (total number of chosen answers were 116).

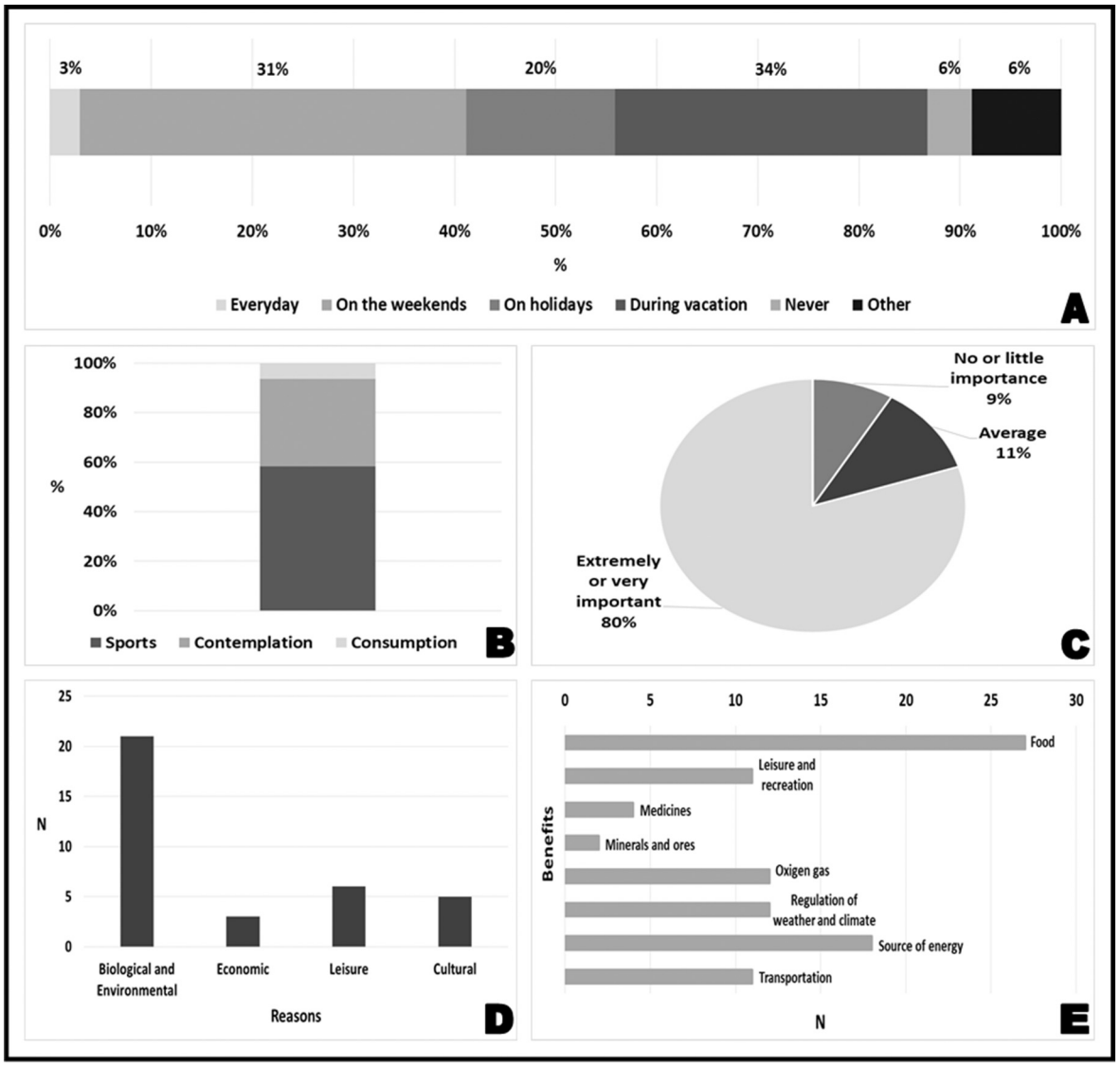

Fig. 4. Responses of students regarding their frequency of trips to the sea or beach (A), activities performed there (B), importance of the marine environment (C), reasons for such importance (D), and ocean's benefits to society (E). Where: % – percentage of responses; N – number of responses which surpass the total number of students as they could choose more than one alternative as answer to the question (Fig. 4B total number of chosen answers were 108 and in Fig. 4E it was 97). In Fig. 4A, the category "on holidays" refers to school holidays throughout the year, while the category "during vacation" refers to the two school recess periods at the beginning and in the middle of the school year.

during the discussion slides. However, their engagement increased significantly when familiar environments were presented. At this point, students began sharing personal experiences related to the ecosystems. The coastal ecosystems class was further complemented by two laboratory experiment sessions (activities 9 and 15), which aimed to provide students with a broad understanding of the bioecological characteristics of the ocean.

The dimensions of "awareness" and "behavior" were explored through laboratory classes addressing environmental impacts on the marine environment, such as marine litter (activities 5 and 17) and ocean acidification (activities 12 and 13). These experiments were conducted over two visits for each topic (a total of four visits): during the first visit, the experiments were set up, and during the second, the results were collected and analyzed by the students. Of the six laboratory activities in the coastal ecosystems and their problems module, four were demonstrative, while in two activities, students submitted activity reports summarizing their findings. Chart 5 provides an overview of the students' development as reflected in these reports.

The dimension of "attitude" was addressed in two key activities. In activity 4 (discussion circle), students were asked to explore the influence of the ocean on humans and terrestrial environments. Their perspectives revealed two predominant views: a utilitarian perspective, focusing on the ocean's contributions to social activities, and an ecological perspective, emphasizing the bioecological characteristics of the marine environment. To expand these perspectives, a mock jury (activity 21) was organized. This activity revolved around one of Brazil's key coastal environments, Guanabara Bay (Rio de Janeiro, 22°47′25"S, 43°9′20"W), with students representing economic agents or environmentalists. Although inferences on perspective changes should be made with caution since the pedagogical strategy used in the two moments were different, it was evident that when mock jury was used critical thinking and argumentation based on scientific texts were encouraged. Fig. 5 presents word clouds generated from students' statements during these two activities which shows this trend. Based on the fact that what was being work was the mobilization of the dimension "attitude" and not a quantitative measurement, the experience registered in the field notes underpins the case for a perspective change in the attitude dimension of students in relation to human influence on ocean.

Chart 5
Activities, questions proposed in reports, student performance categories per question, and sample responses for each performance category, where: % – percentage of answers in each category; N – number of students who submitted an activity report; Good – the response fully met the question goals; Regular – the response partially met the question goals; and Insufficient – the response did not meet the question goals.

Activity	Question	Category	Criteria	%	Sample responses
5 (*N* = 31)	Identifying clean and dirty beaches	Good	To be able to identify all three pairs of clean/dirty beaches	83.3 %	*"These are photos of three beaches, half of which are clean and the other half are polluted."*
		Regular	To be able to identify one or two pairs of clean/dirty beaches	0 %	X
		Insufficient	No response	16.7 %	X
	Beach litter composition	Good	To mention in the response more artificial materials than natural	50 %	*"Bottle, slipper, pan, toilet seat, bag, diaper, beer can, paper, bucket, pipe, cream cheese cup, children's rug."*
		Regular	To mention in the response a higher number of natural materials than artificial	16.7 %	*"Plastic, metal, leaf, branch, coconut, rubber."*
		Insufficient	No response	33.3 %	X
	Causes of marine litter	Good	To be able to list activities related to the consumption, disposal and production of waste	16.7 %	*"Garbage comes from industry, sewage, people and boats."*
		Regular	To be able to list activities related to the consumption and disposal of waste	50 %	*"Dumping garbage into the sea water, people bring disposable things with them and throw them on the sand."*
		Insufficient	To be able to list activities related to the consumption or disposal of waste	33.3 %	*"Garbage comes from sewage, rain or even the sea."*
	Decomposition of marine litter (organic/natural and inorganic/artificial)	Good	To be able to point out that natural materials decompose faster than artificial materials	50 %	*"Leaves decompose faster than a PET bottle."*
		Regular	To only say that natural materials decompose	50 %	*"Organic waste will decompose and recyclable waste will not decompose."*
		Insufficient	No response	0 %	X
	Actions to tackle the problem of marine litter	Good	To be able to indicate actions that influence consumption, disposal and waste production	0 %	X
		Regular	To be able to indicate actions that influence consumption and disposal of waste	100 %	*"Take recyclable waste to recycling to be reused."*
		Insufficient	To be able to indicate actions that influence consumption or disposal of waste	0 %	X
9 (*N* = 34)	Description of marine sediment types	Good	To be able to Identify the three characteristics (color, thickness and space between grains) of the three types of sediments experimentally studied	44.4 %	*"Clay is dark in color, very thin and with short spaces between grains. Sand is a little thicker than clay, has a shiny color and medium space between grains. Gravel is whiter in color, is the thickest and has large spaces between grains."*
		Regular	To be able to Identify two out of the three characteristics (color, thickness and space between grains) of sediments experimentally studied	33.3 %	*"Clay is thin and its color is brown. Sand is more or less fine and its color is yellow. White gravel is thick and its color is lighter."*
		Insufficient	To be able to Identify one out of the three characteristics (color, thickness and space between grains) of sediments experimentally studied	22.2 %	*"The thickest grain is gravel. The thinnest grain is clay. Sand is neither too thick nor too thin."*
	Identification of sediment permeability	Good	To be able to Identify the gravel as the most permeable sediment and be able to relate this with the space among grains which is characteristic of this sediment	66.7 %	*"The most permeable grain is gravel because it has the most space between the grains."*
		Regular	To be able to Identify the gravel as the most permeable sediment without any justification	0 %	X
		Insufficient	To be able to Identify the gravel as the most permeable sediment but with a wrong justificative	33.3 %	*"The most permeable element was gravel because the grains are closer together, without space, thus giving space for water to pass through."*

Two film clubs (activities 6 and 20) were organized to explore how collective societal organization could contribute to addressing the degradation of the ocean, focusing on the "activism" dimension. The first film club featured the case of a peripheral neighborhood in Porto Alegre, Rio Grande do Sul, Brazil (Ilha das Flores), which serves as an open-air garbage dump. Although situated in a different region, the socioeconomic similarities resonated with the students' realities. One student remarked, "There are many Ilha das Flores worldwide". During the discussion, students identified global challenges to addressing the issue of garbage, such as the intense consumption of goods and planned obsolescence. The group concluded that resolving the oceanic garbage problem would require overcoming a production model driven by market demands. The second film club also depicted a peripheral neighborhood, Ilha de Deus in Recife, Pernambuco, Brazil, but this case highlighted a community that collectively organized the sustainable production of marine resources in a mangrove ecosystem. Students observed that "There is no company, but there is plenty of fish to sell and eat", realizing that marine resources could be extracted sustainably without producing continuous waste or depleting natural resources. This discussion underscored the possibility of mitigating marine degradation through collective organization aimed at using ocean resources to meet human needs. Additionally, the "adaptive capacity" dimension was addressed through a didactic game (activity 16) where students matched images and texts to events in the historical development of Guanabara Bay, with a focus on urban-industrial growth. The game facilitated critical discussions on issues like pollution, marine litter, flooding, and ghost ships within a historical-critical framework.

The students' "access and experience" of their city's natural and cultural heritage sites were facilitated through activities such as identifying images related to these sites (activity 3) and, more importantly, participating in four field trips (activities 19, 22, 23, and 24). Following the trips, students were tasked with writing short texts about the places they visited (activity 26) based on four guiding questions: 1) What is the name of the site? 2) Is it a natural or cultural heritage site? 3) Where is the site located? and 4) What are your personal impressions? These activities not only promoted engagement with local heritage but also

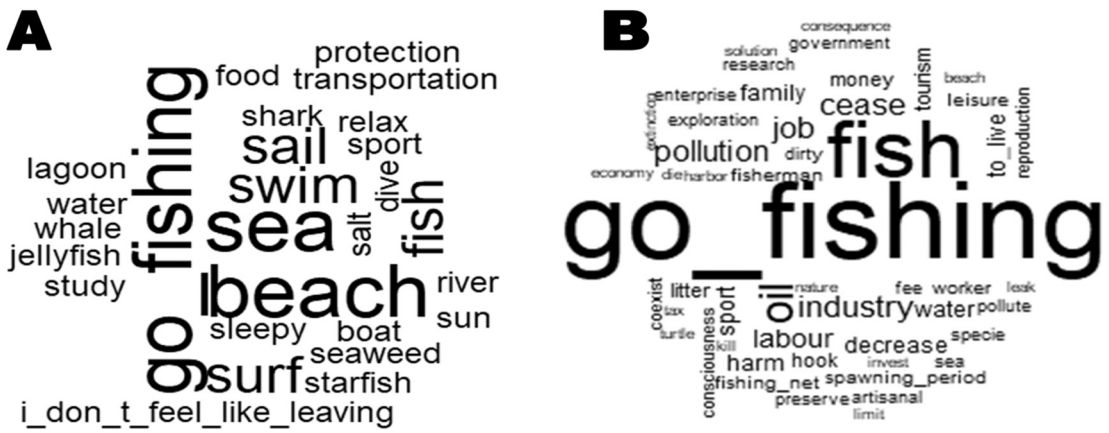

Fig. 5. Word clouds constructed based on students' statements in the discussion circle (A) and the mock jury (B). In (A), a distinct utilitarian perspective is evident through terms such as "go fishing", "surf", "transportation", "food", and "protection", alongside an ecological perspective reflected in words like "shark", "jellyfish", "starfish", "beach", "sea", and "lagoon". In contrast, (B) indicates a shift toward integrating these perspectives, as evidenced by terms such as "preserve", "coexist", "artisanal", "reproduction", "limit", "spawning", "oil", and "extinction". These terms suggest an emerging understanding among students of the importance of balancing the social use of the ocean with practices that ensure the sustainable reproduction of marine natural resources.

played a significant role in enhancing the students' reading and writing skills. Furthermore, they provided opportunities for students to process information sourced from websites, thereby fostering the "trust and transparency" dimension of ocean literacy. Table 2 summarizes the students' impressions of the heritage sites they visited. These impressions, along with photos taken by the students, were organized into a photographic exhibition at the school (activity 27), extending the experience of connecting with natural and cultural heritage to the entire school community.

Table 2
Heritage sites visited and their categorization (natural or cultural), distance from the school in geographic coordinates, and students' impressions of them.

Heritage site	Category	Distance/ coordinates	Impressions
Museu de Arte Contemporânea (Museum of Contemporary Art)	Cultural	11.4 km 22°54′28"S, 43°07′3"W	*"My impressions were good, with an openness to reality. Art is feeling and criticism."*
Museu Janete Costa de Arte Popular (Janete Costa Museum of Folk Art)	Cultural	13.8 km 22°54′13.8"S, 43°7′41"W	*"Inside the museum there are sculptures made of clay and wood, as well as highly elaborate abstract paintings."*
Praia da Boa Viagem (Boa Viagem Beach)	Natural	14.1 km 22°90′79"S, 43°12′83"W	*"This beach is good for fishing and has lots of shells."*
Trilha Caminhos de Darwin[a] (Darwin's Paths Trail)	Natural	14.1 km 22°55′44"S, 42°59′16"W	*"Beautiful place. Fresh air and pleasant climate, super peaceful trail and it has an environmental education area."*
Lagoa de Itaipu (Itaipu Lagoon)	Natural	15.8 km 22°57′40"S, 43°02′03"W	*"Lots of natural beauty in one place, mountains and very rich vegetation. You can relax, practice water sports, enjoy with family and friends."*
Museu de Arqueologia de Itaipu (Itaipu Archaeology Museum)	Cultural	17.1 km 22°58′16"S, 43°02′41"W	*"The museum has ancient works made by shell mound workers, as well as whale bones."*
Praia de Itaipu (Itaipu Beach)	Natural	17.1 km 22°58′15"S, 43°02′44"W	*"On the beach there are rocks, shells, fish and people."*
Fazenda Itaocaia[b] (Itaocaia Farm)	Cultural	19.9 km 22°55′53"S, 42°58′12"W	X

[a] Trail consisting of 12 spots where Charles Darwin (1809–1882) passed in April 1832 during his iconic voyage aboard the ship H. M. S. Beagle.

[b] Located in an old sugar cane mill, the farm is a residence open to educational tourism, which addresses both the history of slavery and biodiversity in the region.

The "communication" dimension was addressed through discussions on fake news about the ocean and the importance of verifying information sources (activity 14). The "emotional connections" dimension was cultivated by fostering emotional ties to the ocean through various activities, including contact with marine biodiversity (activities 7 and 10), the creation of marine environment figures ($n = 36$) using Tangram puzzles (activity 18), and the production of stories ($n = 24$) inspired by the constructed images (Fig. 6). Emotional engagement was further enhanced through field trips (activities 19, 22, 23, and 24). Additionally, the historical consequences of human exploration of the ocean during the pre-Columbian period were discussed through the reading of a popular science text for children about shell mounds (activity 11; Silva et al., 2018).

3.3. Evaluation

3.3.1. Pre- and post-tests

Regarding students' knowledge about the marine environment (Chart 6), their understanding can be classified as moderate (correct answer rate between 60 and 80 %) for questions addressing the relationship between society and the ocean, such as uses, resources, and climate regulation. However, their knowledge is low (correct answer rate of 40 % or less) for questions involving scientific concepts, such as biodiversity and chemical oceanography. Following the intervention, a slight improvement in students' knowledge was observed, but the results were not statistically significant. One characteristic of students in situation of school retention is their general lack of interest in formal school activities, which may explain the absence of significant differences between pre- and post-test results. This aligns with the findings that the "knowledge" dimension is the area where students exhibit the most resistance.

3.3.2. Interviews

The network of similarities generated from individual interviews with students reveals a main axis composed of the words "Fazenda Itaocaia", "Trilha Caminhos de Darwin", "ocean", "class", "activity", "learn", "animal" and "beach", with four of these words referencing field trips (Fig. 7A). The prevalence of these words in the main axis of the network suggests that students showed greater interest in activities involving field trips. Secondary axes further reinforce this

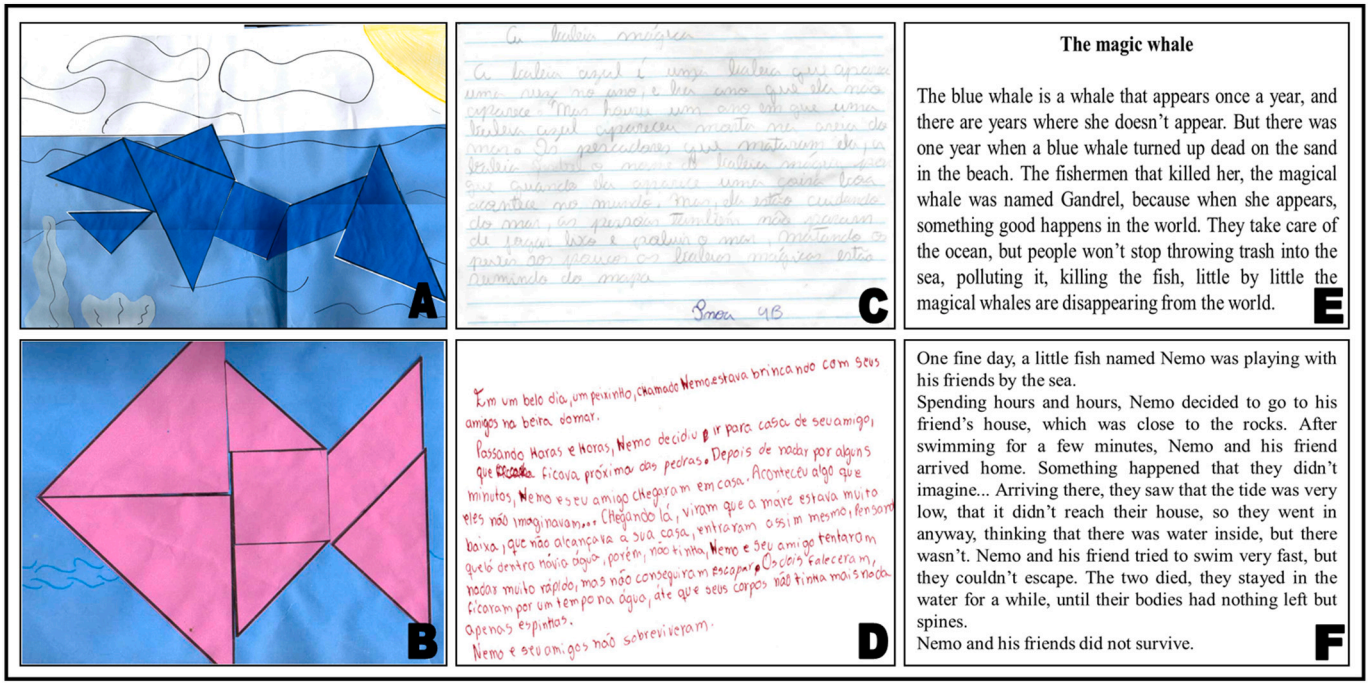

Fig. 6. Images of a whale (A) and a fish (B), both constructed from a Tangram puzzle (Activity 18, Table 1); in addition to the stories created by the students for them in Portuguese (C) and (D) and their translation in English (E) and (F), showing the mobilization of the dimension "emotional connections" with marine environments and their biodiversity.

Chart 6

Percentages of students answers in each of the three categories offered (correct/incorrect/"Don't know") in pre- ($N = 35$) and post-tests ($N = 33$) assessing knowledge about ocean. *P*-value stands for Mann-Whitney tests comparing pre and post tests answers for each question.

Question	Pre-test			Post-test			p-value
	Correct	Incorrect	"I don't know"	Correct	Incorrect	"I don't know"	
Percentage of the planet's surface covered by ocean	74.3 %	25.7 %	0 %	75.8 %	24.2 %	0 %	0.2534
There is a single ocean with varying characteristics	40 %	60 %	0 %	42.4 %	57.6 %	0 %	0.8459
Seawater salt source	40 %	25.7 %	34.3 %	57.6 %	21.2 %	21.2 %	0.1523
Tectonic activity, sea level changes and waves can alter coastal landscapes	91.4 %	8.6 %	0 %	90.9 %	9.1 %	0 %	0.9502
Source of evaporation from which most of the rain originates	65.7 %	20 %	14.3 %	39.4 %	24.2 %	36.4 %	0.0316
The ocean has a major influence on controlling climate and climate change	80 %	20 %	0 %	72.7 %	27.3 %	0 %	0.4883
Environment in which most groups of living beings are found	25.7 %	60 %	14.3 %	54.5 %	36.4 %	9.1 %	0.0859
Group to which most living beings found in the ocean belong	11.4 %	71.4 %	17.1 %	3 %	63.6 %	33.3 %	0.0528
Society obtains food, medicine, minerals and energy resources from the ocean	88.6 %	11.4 %	0 %	87.9 %	12.1 %	0 %	0.9387
People who live far from the ocean do not cause ocean pollution	74.3 %	25.7 %	0 %	78.8 %	21.2 %	0 %	0.6702
Percentage of the ocean, other than the surface, that has already been studied	37.1 %	51.4 %	11.4 %	45.5 %	42.4 %	12.1 %	0.6464
Why it's important to study the ocean	62.9 %	37.1 %	0 %	66.7 %	33.3	0 %	0.8849

interpretation, linking "explain" to "Fazenda Itaocaia", "good" and "experience" to "field trip" and "learn" to "walk". These connections indicate that students associated field trips with gaining new knowledge. As one student remarked during the interview, "I had never imagined the things I saw outside of school, I had never imagined that I would see this". Another student noted, "when we go out, we can understand things better", further emphasizing the role of field trips in enhancing comprehension.

The network of similarities features a main axis composed of the words "know", "work", "class" and "student" (Fig. 7B). The word "know" is connected to "field trip", "practice" and "theory", while "work" is linked to "practical" and "ocean". These connections highlight the teachers' association between practical activities, such as field trips and laboratory lessons, and the opportunity to deepen theoretical understanding. As one teacher stated, "within practice, you work on the issue of theory". The word "know" also connects to "bus", "time", "financial", "support" and "opportunity", while "work" is connected to "transportation", "school" and "environment", indicating that the school's infrastructure is a key factor influencing the execution of marine environment-related activities. Meanwhile, "class" is linked to "project", "interest" and "activity", suggesting that part of the students' interest regarding the project comes from the activities that were developed, which involved aspects such as "game", "reality", and "groups". As one teacher observed, "everything that goes beyond what is considered a class in itself, they like more". At last, the connection of the word "student" with "understand" and "important" indicates that teachers believe these types of classes had a positive effect on students' knowledge about "science" and "art".

In the focus groups conducted with students, a thematic analysis identified six main themes, further divided into 20 subthemes, with a total of 137 mentions (Table 3). The most frequently discussed theme was environmental impacts, accounting for 24.8 % of mentions, while the least frequent theme addressed characteristics of the ocean (10.1 %). Among the subthemes, the most mentioned was the role of theory in the intervention (13.2 %), whereas eutrophication and climate change were the least mentioned, each comprising 1.5 % of the mentions. Beyond the

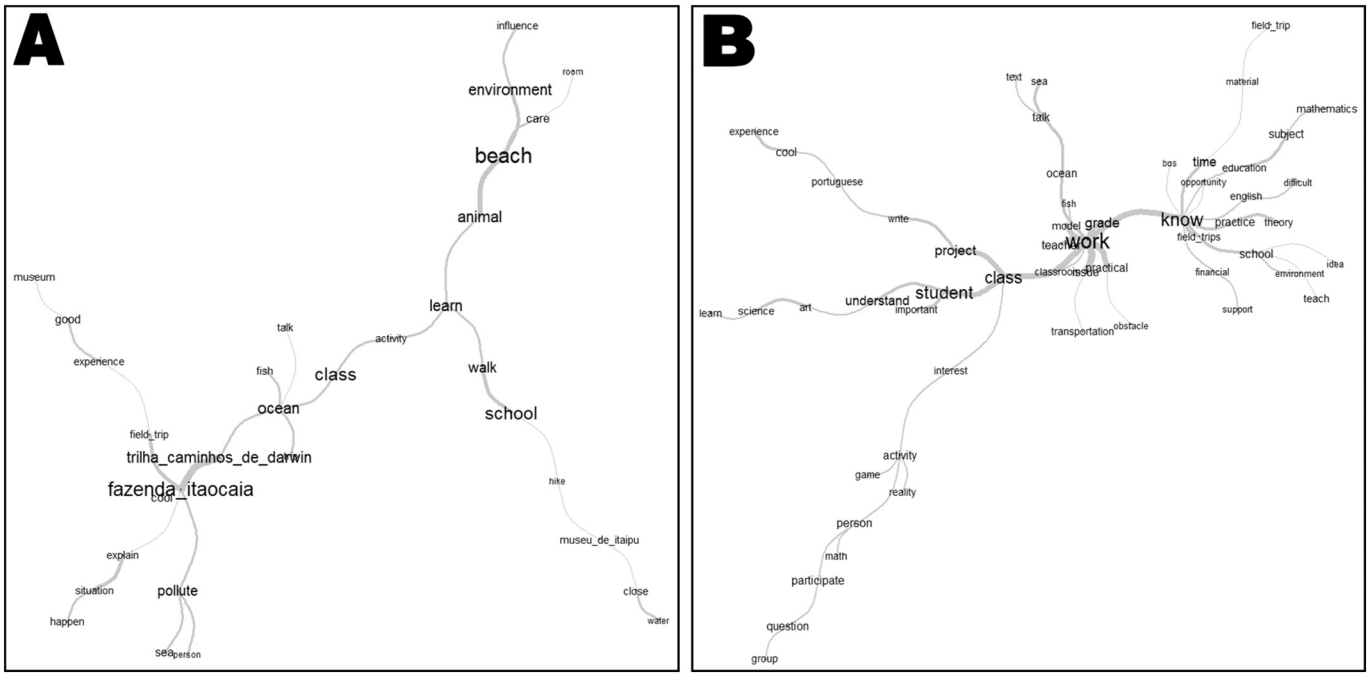

Fig. 7. Similarity networks produced from the textual corpus of individual interviews with students (A) and teachers (B).

Table 3
Themes and subthemes identified in interviews with focus groups of students, where: N –number of times a subtheme was identified in the students' statements; and % – percentage of occurrence of the subtheme in relation to all others.

#	Themes	Subthemes	N	%
1	Ocean features	Ecosystems	5	3.6
		Biodiversity	4	2.9
		Importance	3	2.1
		Sea-land connectivity	2	1.5
2	Ocean preservation	Practices	15	10.9
3	Environmental impacts	Litter	10	7.3
		Extreme events	6	4.4
		Oil spill	5	3.6
		Overfishing	5	3.6
		Oceanic acidification	4	2.9
		Eutrophication	2	1.5
		Climate change	2	1.5
4	Perspectives about the degraded state of the ocean	Historical-concrete[a]	8	5.8
		Blue justice[b]	7	5.1
		Econihilist[c]	7	5.1
		Individual-centered[d]	6	4.4
5	Relation between theory and practice	Theory's function	18	13.2
		Pratice's function	12	8.9
6	General aspects of the intervention	Difficulties	9	6.6
		Facilities	7	5.1
TOTAL			137	100.0

[a] The Historical-concrete perspective relates the causes of environmental impacts on the ocean to the economic basis of society. In this sense, the possibility of a sustainable relationship with the ocean is directly related to overcoming a system based on the ever-increasing production of commodities.

[b] The Blue justice perspective assumes that there are asymmetric power relations between economic agents and traditional populations that use the marine environment as a means of subsistence.

[c] The Econihilist perspective is a pessimistic stance that assumes there is no way out of the current state of ocean degradation.

[d] The Individual-centered perspective attributes the degraded state of the ocean to the harmful behavior of individuals.

quantitative description, the analysis revealed that students engaged with both oceanic knowledge (predominantly reflected in the first three themes) and broader reflections on the causes and solutions for ocean degradation (fourth theme). Students also reflected on the interplay between theory and practice within the intervention (fifth theme). Additionally, the analysis highlighted the facilitators and barriers experienced by students during the intervention (sixth theme).

4. Discussion

As ocean degradation intensifies, the need for sustainable use of the marine environment becomes increasingly urgent, requiring the promotion of ocean literacy across diverse countries, audiences, and educational segments (Santoro et al., 2017). Disseminating only scientific facts about the global state of the ocean has proven ineffective in shifting public perspectives; therefore, it is recommended to address ocean-related issues within a local context (Barracosa et al., 2019). This approach has been implemented across various countries and continents, including Australia, focusing on initiatives in the Great Southern Reef (Freitas et al., 2025); Europe, with efforts to promote ocean literacy in the Mediterranean Sea (Mokos et al., 2020); Brazil, through partnerships between schools and public institutions in the southeastern region (Christofoletti et al., 2022; Pazoto et al., 2023b); and Portugal, with the development of the Blue Schools program (Costa et al., 2024; Schio and Reis, 2024). This work contributed to the effort to regionalize ocean literacy, aiming to establish a meaningful dialogue with the students' lived experiences. For instance, it facilitated discussions on the issue of litter in natural and cultural environments—a problem familiar to the students. The discussions highlighted that addressing this issue requires solutions extending beyond individual or local perspectives, emphasizing the need for collective and global action aimed at fostering a new approach to wealth production (Clark and Longo, 2018).

While evidence suggests that regionalization contributes to promoting ocean literacy, acquiring scientific knowledge about the ocean can encourage reflections on its ecological importance and the natural limits of its exploitation (Ghilardi-Lopes et al., 2019; Uyarra and Borja, 2016). However, research indicates that the knowledge dimension can be challenging to mobilize, particularly among elementary school

students (Amaral et al., 2014; Costa et al., 2024; Fauville et al., 2018; Stoll-Kleemann, 2019). Dupont and Fauville (2017) argue that this difficulty may stem from the abstract nature of generalized knowledge, such as global aspects of the ocean (*e.g.*, ecology, chemical, and physical oceanography), which often feels disconnected from students' realities. To address this challenge, adopting a strategy that contextualizes knowledge to align with the specific realities of the location, school, and students involved can be effective (Freire, 2000). To tackle this problem it was used local realities such as that of Guanabara Bay (a post card from Rio de Janeiro which integrates student's life) as case study and the strategy showed a good effect. At this point, students began sharing personal experiences related to the ecosystem, which highlights the importance of incorporating students' realities into the educational process, as emphasized by Freire (2000).

McKinley et al. (2023) emphasized that incorporating all ten dimensions of ocean literacy is an effective strategy to overcome challenges associated with the knowledge dimension, highlighting that ocean literacy encompasses more than just cognitive understanding. However, many ocean literacy initiatives continue to rely on the knowledge deficit model (Umuhire and Fang, 2016; Shellock et al., 2024). In contrast, a growing body of research focuses on integrating additional dimensions beyond knowledge into their programs (Boaventura et al., 2021; Boubonari et al., 2013; Cummings and Snively, 2000; Koulouri et al., 2022; Wen and Lu, 2013). For instance, Pazoto et al. (2023b) implemented an educational intervention that addressed seven dimensions of ocean literacy, leading to increased student interest and engagement with the marine environment, as well as a closer connection between students and the coastal and marine ecosystems of their city. Similarly, Schio and Reis (2024) utilized all ten dimensions of ocean literacy in an educational program that fostered essential ocean citizenship skills, including knowledge, values, critical thinking, and attitudes. In the educational intervention described in this study, all ten dimensions of ocean literacy were also mobilized. This approach contributed to the development of skills such as reading, writing, argumentation, and collaboration, all of which are considered critical tools for active citizenship. Results obtained especially from mock jury and tangram puzzle showed here are good examples of what is being saying about mobilizing the dimensions with gain of educational skills. Students were able to expand and practice creativity in both dimensions emotional and rational.

Savegnago and Castro (2020) asserted that academic performance varies across socioeconomic groups, a disparity directly tied to unequal access to the conditions necessary for educational progression. For example, students who are in a situation of school retention often contend with stressful transportation, lack access to books, rest, or quiet spaces to study, and are frequently involved in informal labor markets (Termes et al., 2024). Furthermore, Savegnago and Castro (2020) argued that the traditional school system fails to address these disparities, instead applying uniform solutions to unequal conditions. In such circumstances, held-back students may perceive the school system as an oppressive structure and develop an active resistance toward what they view as the root of their challenges: the formal education system and its conveyed knowledge. To address this, the educational intervention described in this study employed activities that presented knowledge from alternative perspectives, such as field trips and laboratory experiment sessions. These activities successfully ignited students' interest and engagement. By mobilizing dimensions like awareness, behavior, emotional connections, and access and experience, the intervention not only facilitated a connection to knowledge but also positively influenced students' relationship with the school environment. Sayings captured in interviews (individual or focus group) from both, students and teachers, gave us strong evidence that students' behavior in relation to school life changed over the intervention.

Research has highlighted the importance of employing diverse teaching strategies to foster critical discussions with students about ocean-related issues (Bettencourt et al., 2023; Goodale and Sakas, 2018; Santoro et al., 2017). Interventions limited to a few hours on a single day or spread over just a few days often face significant challenges in achieving the goal of fostering informed appreciation and conscious opinions about oceanic issues (Barracosa et al., 2019; Boaventura et al., 2021; Fielding et al., 2019; Hunt, 2021; Schio and Reis, 2024; Stevens, 2021). In response to these limitations, this study extended its intervention over an entire academic year, conducting 30 sessions that included a wide range of activities such as lectures, film clubs, seminars, laboratory experiment sessions, hands-on experiences, and field trips. By the end of the program, many students seems to be softened their Individual-centered (which overlook the structural causes of oceanic problems) and Eco-nihilist perspectives (which deny potential solutions for the oceanic Anthropocene) toward a more Historical-concrete and Blue justice perspectives, which emphasize a historical and economic understanding of marine degradation.

As noted by Shellock et al. (2024), quantitative methods dominate the analysis of data in ocean literacy studies. While these methods are valuable, they may limit the theoretical understanding of changes that occur during educational interventions, particularly in dimensions like adaptive capacity, emotional connections, activism, and trust and transparency. To address this limitation, this study employed a combination of quantitative and qualitative analysis methods, allowing for a comprehensive evaluation of how the ten dimensions of ocean literacy were mobilized. These methods captured shifts in students' perceptions, conceptions, values, and judgments regarding oceanic issues and their solutions. Additionally, evaluations by both students and teachers indicated that the program enhanced students' concentration and engagement in school activities. Similar findings were reported in an ocean literacy teacher training program in Australia, where educators' activities resulted in the active participation of students who previously struggled with focus and school tasks (Freitas et al., 2025).

In summary, this paper detailed the design, implementation, and evaluation of a long-term educational intervention conducted with students in situation of school retention from a public school in Rio de Janeiro, Brazil. The program, structured to mobilize all ten dimensions of ocean literacy, emphasized the students' social experiences and local connections to the ocean. During the intervention, students exhibited active resistance to the knowledge dimension. Although there is evidence that misconceptions about the marine environment hinder the incorporation of oceanic knowledge by students across educational levels (Chang et al., 2023; Mogias et al., 2019; Mokos et al., 2020), the fact that the educational intervention was conducted with students in situation of school retention suggests that this resistance to knowledge stems from the banking concept of education (Freire, 2000). This concept represents an educational system that, by labeling students as retained, shifts responsibility for academic failure onto the students themselves, while disregarding the social and economic causes that disproportionately affect educational progress. This prompts students to actively reject both the educational system and the scientific knowledge disseminated in schools. To address this, knowledge was integrated with the other nine dimensions of ocean literacy, fostering a more holistic engagement. The intervention stimulated key citizenship-building skills such as reading, writing, argumentation, and collaboration. Furthermore, students' interest and engagement improved significantly, creating a stronger connection to both the knowledge being conveyed and the school environment. Field trips and laboratory experiment sessions were particularly impactful, as highlighted by both students and teachers, fostering self-confidence and self-esteem among participants. The most significant outcome, however, was a shift in students' perspectives toward a Historical-concrete (or Blue justice) understanding of ocean issues. This approach enabled students to move beyond the simplistic view that ocean degradation stems from individual behaviors. Instead, they recognized that degradation is driven by a mode of production prioritizing profit over the preservation of marine resources. Therefore, this study contributes to ocean literacy education by addressing an often-overlooked segment of students. It demonstrates the

potential for educational interventions to engage diverse social groups in rethinking their relationship with the marine environment. By doing so, it aims to collectively build a future where societal development and ocean sustainability coexist in a fundamentally transformed relationship with the ocean.

At this point is important to note that our worst results were related to the dimension of knowledge. This is at odds with the results of educational interventions that focus on knowledge dissemination, which usually show an increase in students' ocean knowledge at the end of the activities (Amaral et al., 2014; Ashley et al., 2019; Bettencourt et al., 2023; Boaventura et al., 2021; Cummings and Snively, 2000). One of the possible reasons for this result is the situation of school retention of the students, an educational segment that has not yet been addressed in ocean literacy actions. In fact, as more ocean literacy activities are carried out with retained students, it is possible that the need to go beyond practices based exclusively on knowledge will be perceived, allowing the appreciation of students' significant experiences with the marine environment in all its diversity of dimensions (Gough, 2017). In contrast with that results, for the other nine dimensions could be considered fairly well, such as those related to the dimension of access and experience, it showed great engagement and positive mentions for all the evaluation done. This corroborates results found in other ocean literacy interventions with students and teachers (Freitas et al., 2025; Pazoto et al., 2023b). Furthermore, it is important to mark that despite have being an ocean literacy intervention issues such as climate literacy, energy literacy, forest literacy and other correlate themes have had room in the intervention when activities regarding natural and cultural heritage, litter in natural environments, shell mounds, field trip crossing Atlantic Forest (Darwin's Path Trail) *etc.* were implemented. Ocean literacy although a specific issue has an interdisciplinary approach given the ocean has no existence apart from planet Earth, and planet Earth exists not for humans without the ocean.

Statements and declaration

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This manuscript is an original work that has not been submitted to nor published anywhere else.

CRediT authorship contribution statement

Luca Ribeiro Mendes Nicola: Writing – original draft, Methodology, Investigation. **Victor Hugo Cordeiro Vianna:** Writing – original draft, Methodology, Investigation. **Carmen Edith Pazoto:** Writing – review & editing, Methodology, Investigation. **Michelle Rezende Duarte:** Writing – review & editing, Methodology, Formal analysis. **Edson Pereira Silva:** Writing – original draft, Supervision, Methodology, Conceptualization.

Declaration of competing interest

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Data availability

Data will be made available on request.

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