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Promoting ocean literacy among students in Brazilian schools

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ABSTRACT

Promoting the principles, concepts, and dimensions of Ocean Literacy (OL) among children and youth is essential for enhancing society's understanding of the ocean's complexity and the causes and consequences of its degradation. This study details a project conducted over a year with 235 students from a public school in Rio de Janeiro, Brazil, aged 8 to 15. Developed in partnership with schoolteachers, the activities encompassed theoretical lessons, laboratory experiments, field trips, and reading circles. These were grounded in the students' local context and integrated into the school curriculum. The project was evaluated through questionnaires and focus group interviews. Findings revealed not only learning and changes in attitude but also increased student engagement and a revitalized school environment. This project can be adapted for other regions and audiences.

1. Introduction

Initiated in the U.S. in 2004, Ocean Literacy (OL) addresses the underrepresentation of oceanic topics in formal education. OL delineates the reciprocal influences between the ocean and humanity (Ocean Literacy Network, 2020). The then-prevalent omission of ocean-related topics in schools was believed to underlie the general population's scant awareness of the ocean's significance in their lives (Santoro et al., 2017). Consequently, a foundational set of knowledge about the ocean, which students should possess by the end of their schooling, was proposed. This knowledge was distilled into seven essential principles and 45 core concepts of OL (Schoedinger et al., 2010). An ocean-literate individual is expected to grasp the ocean's importance to humanity, articulate it well, and make informed decisions concerning the ocean and its resources (Ocean Literacy Network, 2020).

During OL's first decade, research primarily aimed to gauge the ocean knowledge and awareness levels among different demographics, such as teachers (e.g., Boubonari et al., 2013), school-aged children and teens (e.g., Ballantyne, 2004), and the broader public (e.g., Steel et al., 2005). These studies consistently reported knowledge levels ranging from limited to moderate, signaling a clear need for initiatives to bolster society's ocean literacy (Tran et al., 2010; Strang et al., 2007). Moreover, these investigations posited that efforts should mainly target school-aged children due to their potential ripple effect on peers and families, fostering attitudes and behaviors that champion ocean sustainability (Hartley et al., 2015; Tran et al., 2010).

In this vein, Plankis and Marrero (2010) suggested a bespoke K-12 curriculum based on OL principles for a marine science elective. Similarly, Mokos et al. (2020) initiated an OL-centric educational intervention for 8 to 9-year-old children, in celebration of the "European Maritime Day." In Brazil, Stefanelli-Silva et al. (2019) rolled out a project in a school targeting 10 to 11-year-olds, emphasizing marine and coastal environment education throughout the term.

Recent discourses on OL underscore that shifts in ocean-related attitudes and behaviors are not exclusively driven by knowledge and awareness. The public's connection with the ocean also plays a pivotal role (Stoll-Kleemann, 2019; Kollmuss and Agyeman, 2002). Brennan et al. (2019) thus proposed broadening the original OL educational framework to include six dimensions: (1) awareness, (2) knowledge, (3) attitudes, (4) communication, (5) behaviour, and (6) activism. McKinley et al. (2023) further augmented this list with four additional dimensions: (7) emotional connection, (8) access and experience, (9) adaptive capacity, and (10) trust and transparency. As such, efforts to nurture OL in diverse audiences should holistically embrace all ten OL dimensions. This comprehensive approach can catalyze the transformation of ocean knowledge into meaningful behavioral shifts and proactive measures promoting ocean sustainability (McKinley et al., 2023; McKinley and Burdon, 2020).

The project titled "*Onda Cultural nas Escolas*" (translated as "Cultural Wave in Schools") is an initiative by the Laboratory of Marine Genetics and Evolution at the Federal Fluminense University (LGME-UFF). It aspires to design activities for both formal and informal educational arenas, grounded in OL's principles, concepts, and dimensions, with a special emphasis on school-aged audiences. This study details the

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Table 1
Participating classes, school shifts, number of students and their average age, and number of participating teachers in the developed activities.

Class	Shift	Number of students	Student average age	Number of participating teachers
3rd A	Afternoon	23	8–9 years	1
3rd B	Afternoon	25	8–9 years	1
5th A	Afternoon	31	10–11 years	1
5th B	Afternoon	28	10–11 years	1
5th C	Afternoon	30	10–11 years	1
6th	Morning	33	11–12 years	2
7th	Morning	31	12–13 years	1
9th	Morning	34	14–15 years	1
Total		235	TOTAL	9

endeavors and outcomes of this project, undertaken during the 2022 school year at a public elementary school in Niterói, Rio de Janeiro State, Brazil. The initiative aimed to craft distinct activities in tandem with school educators, spotlighting OL content. This effort capitalized on the city's rich historical, cultural, and natural legacies and seamlessly integrated the newly developed content into the existing school curriculum. The research question of this study was 'how effective is an integrated theoretical, laboratorial, hands-on lessons and field trips educational program designed in partnership with school teachers is able to sensitize children toward different dimensions of Ocean Literacy?'. The hypothesis was that the intervention promoted would positively affect children (beyond knowledge enlightment), therefore, a multiple approach (field notes, post-activity questionnaires and focus group interviews) was taken to infer the results in dimensions such as changes in emotional connections, attitude, awareness etc.

2. Materials and methods

2.1. School and participant selection

In 2021, contact was made with a public school in Niterói, Rio de Janeiro, Brazil, which had 51 schoolteachers and 808 enrolled students. The school catered to students from 6th to 9th grade in the morning shift and from 2nd to 5th grade in the afternoon shift, encompassing the elementary school level. The school was selected based on three criteria: its location in an economically disadvantaged area, its service to a low-income population, and its focus on the first and second segments of elementary education for students aged 7 to 15. During the initial contact, the project proposal was presented to the school administration, and two meetings were scheduled: one with the morning shift teachers and another with the afternoon shift teachers. During these meetings, a lecture on Ocean Literacy was given, and the proposal and its objectives were also discussed. Out of the 40 teachers who attended these meetings, 22 expressed interest in participating. Subsequently, partnerships were formed with nine teachers (four from the morning shift and five from the afternoon shift). The project was then implemented weekly throughout the entire school year of 2022, from March to October. These details are summarized in Table 1.

2.2. Activities

The proposed activities centered on addressing specific concerns identified in discussions with the partner teachers. These concerns encompassed marine litter, the desire for increased marine-themed content in classes, environmental degradation, and the promotion of reading and writing skills. All activities were designed to align with the curriculum and to incorporate the principles, concepts, and dimensions of Ocean Literacy (Ocean Literacy Network, 2020; McKinley et al., 2023). A total of 14 activities were outlined, as presented in Table 2 and described in relation to its details of objectives, duration, and number of teachers and classes involved in Table 3.

Table 2
Developed activities, teaching strategy used, and respective relationship with the principles, concepts, and dimensions of ocean literacy (Ocean Literacy Network, 2020; McKinley et al., 2023).

Activity	Teaching strategy	Ocean literacy	
		Dimension	Principle (concept)[a]
1. Cultural, historical, and natural heritage	Lecture lesson	Knowledge Awareness	1 (A, F, G) 4 (A, C) 6 (A, B, C)
2. Litter in natural heritage sites	Lecture and hands-on lesson	Knowledge Awareness Behaviour Activism Attitude	1 (C, F, G) 6 (D, E, G)
3. Marine and coastal organisms	Hands-on lesson	Knowledge Awareness Access and Experience Emotional Connections	5 (C, D, E, F, H, I)
4. Field trip to Itaipu Lagoon, Itaipu Beach, and Itaipu Archaeological Museum	Field trip	Knowledge Awareness Behaviour Activism Attitude Access and Experience Emotional Connections	1 (A, G) 4 (A, C) 5 (F, I) 6 (A, B, C, E, G)
5. Observations of biological material and litter found in the natural environment	Hands-on lesson	Knowledge Awareness Behaviour Attitude Activism	1 (C, F, G) 5 (C, D, E, F, H, I) 6 (D, F, E, G)
6. Reading circle	Shared reading	Knowledge Awareness	1 (A, G, H) 5 (A, C, D) 6 (A, B, C, D, G)
7. Field trip to Boa Viagem Beach, Contemporary Art Museum, and Janete Costa Museum of Popular Art	Field trip	Knowledge Awareness Activism Attitude Access and Experience Emotional Connections	1 (A, G) 4 (A, C) 6 (A, B, C, E, G)
8. Observations of biological material and litter found in the natural environment	Hands-on lesson	Knowledge Awareness Behaviour Activism Attitude	1 (C, F, G) 5 (C, D, E, F, H, I) 6 (D, F, E, G)
9. Decomposition Bottles	Hands-on lesson	Knowledge Awareness	1 (C, F, G, H) 6 (D, E, F, G)
10. Ocean acidification	Lecture and hands-on lesson	Knowledge Awareness Behaviour	3 (A, B, E, F, G) 4 (C) 6 (A, D, E)
11. Field trip to Darwin's path trail and Itaocaia farm	Field trip	Knowledge Awareness Behaviour Activism Attitude Access and Experience Emotional Connections	1 (G) 4 (B)
12. Post-field trip activity	Hands-on lesson	Knowledge Awareness	1 (G) 4 (B)
13. Formation and diversity of sediments	Lecture and hands-on lesson	Knowledge Awareness	2 (A, C, D)
14. Seawater properties	Lecture and hands-on lesson	Knowledge Awareness	1 (A, B, C, E)

[a] The complete description of the principles and concepts of Ocean Literacy can be found at: https://oceanliteracy.unesco.org/wp-content/uploads/2020/09/OceanLiteracyGuide_V3_2020-8x11-1.pdf (accessed on May 22, 2023).

2.3. Data collection

Data collection was undertaken using field notes to record observations of the environment and participant interactions. These notes also documented the researchers' impressions, offering a wider social and temporal context to aid data analysis (Kapoor et al., 2023; Phillippi and Lauderdale, 2018). Echoing the approach of Plankis and Marrero (2010), the field notes incorporated comments from partnering students and teachers, as well as observations of behaviors and levels of engagement during the activities.

Post-activity questionnaires were handed out to students to gather insights about their opinions, perceptions, values, and overall experience. These questionnaires allow participants to express themselves without direct influence from researchers (Gil, 2002). The questionnaires combined open-ended and closed-ended queries that addressed: (1) satisfaction with the activities, (2) perceived learning from each activity, (3) favored and least favored aspects of the field trip, and (4) an open section for any additional feedback. The questionnaire was not given to 3rd-grade students due to their limited literacy skills. For 5th-grade students with reading and writing challenges, the questionnaire was mainly comprised of closed-ended questions. The contents of both questionnaires can be found in Charts 1 and 2.

To collect evaluative feedback from the partner teachers about the activities, focus group interviews were held. Focus groups entail interactive discussions among participants, facilitated by a researcher, to

Table 3
Description and goals of the developed activities, durations, number of teachers and classes involved.

Activity	Description and goals	Duration	Number of teachers	Teacher training	Number of classes	School grade
1	Students were shown printed photos of cultural, historical, and natural heritage sites in their city to identify, locate, and describe their significance and use.	1 class	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th
2	Students were shown printed photos of three beaches in two situations: clean and littered. The goal was to discuss types of litter, their origins, their relationships with consumption patterns, and individual and collective ways to reduce litter production. At the end of the activity, decomposition bottles were assembled with organic and inorganic waste for observation after 4 months (activity 9)	1 class	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th
3	A collection of organisms that live in marine and coastal environments was presented to students. Using hand lenses, they observed the characteristics of these animals and were prompted to think about their adaptations, habits, and relationships with the environment and humans.	2 classes	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th
4	Students visited two natural ecosystems, interacting with living and non-living elements. They collected biological material and litter for analysis back at school. Additionally, they visited a museum with a permanent exhibition of archaeological samples from the region and a traveling exhibition showcasing sediment samples and canoes from various parts of the world.	7 classes	3	Sciences and Pedagogy	5	3rd, 6th, 7th and 9th
5	During the field trip, students analyzed the biological material collected, such as shells, plant seeds, and animal body parts found on the beach. Additionally, they classified the collected litter, distinguishing its types and origins.	1 class	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th
6	Students were engaged in a shared reading of the children's book “Suvaco no Mundo dos Corais” (Suvaco in Coral World in English; Favero, 2021), followed by a discussion on the marine organisms and environments presented therein	2 classes	6	Portuguese Language and Pedagogy	6	3rd, 5th and 6th
7	Students were taken to an urban beach to observe the area's characteristics and collect biological material and litter for later analysis back at school. Additionally, they visited two museums in the city	7 classes	4	Sciences, and Pedagogy	6	5th, 6th, 7th and 9th
8	During the field trip, students analyzed the biological material collected, such as shells, plant seeds, and animal body parts found on the beach. Additionally, they classified the collected litter, distinguishing its types and origins.	1 class	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th
9	Students opened the decomposition bottles, examining the organic and inorganic waste inside. They engaged in discussions about material decomposition time and explored individual and collective methods to reduce litter production.	1 class	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th
10	This activity extended over two weeks of classes. In the first week, students discussed concepts of pH and types of pollution affecting seas and oceans. The focus was on environmental issues resulting from increased carbon dioxide concentration in the atmosphere and ocean acidification. The week concluded with the assembly of an experiment to investigate the effects of acidification on biological materials. In the second week, students observed the results of the experiment and discussed the effects of ocean acidification on marine life.	4 classes	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th
11	Students retraced the path taken by the evolutionist Charles Darwin during his visit to Niterói City. They followed the trail through the coastal ecosystem of the Atlantic Forest to Itaocaia Farm, where Charles Darwin also visited.	7 classes	1	Sciences	3	6th, 7th and 9th
12	Through photographic records, students revisited the locations they had previously visited, reflecting on the significance of the Theory of Evolution and its connection to the origin and biodiversity present on the planet.	1 class	2	Sciences and Spanish Language	3	6th, 7th and 9th
13	Students received samples of sandy and clayey sediments to observe their characteristics, pondering the origins of these sediments and the reasons behind their regional variations. Moreover, they conducted an experiment to investigate the permeability of different sediments, drawing connections between the observed characteristics and the organisms present in each region	2 classes	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th
14	Students performed four experiments to ascertain specific properties of seawater, including salinity, density, and specific heat.	2 classes	8	Sciences, Spanish Language and Pedagogy	8	3rd, 5th, 6th, 7th and 9th

1) Put an X on the smiley face that represents the grade you would give to the activities of the "*Onda Cultural nas Escolas*" project?

1 2 3 4 5

2) Why do you believe the project deserves that grade?

3) Put an X on the smiley face that represents how much you liked each activity:

a) Class: b) Experience: c) Reading circle: d) Field trip:

1 2 3 4 5

4) Do you believe you learned something from these activities?

Yes ( ) No ( )

5) Put an X on the smiley face that represents how much you learned about each of the activity themes:

a) Cultural and natural heritage of Niterói: b) Human activities' impact on marine litter accumulation: c) Differences and decomposition times of organic and inorganic waste:

1 2 3 4 5

d) Marine organisms: e) Sediments in marine environments: f) About the ocean and its characteristics: g) About the importance of the marine environment:

1 2 3 4 5

6) What did you like the LEAST about your field trip?

7) What did you like the MOST about your field trip?

8) Leave a comment for the teachers and monitors who brought the "*Onda Cultural nas Escolas*" to your school.

Chart 1. Questionnaire administered to 5th-grade students.

delve into the topic of interest (Onocko-Campos et al., 2017). Two focus group interviews were arranged: one with partner teachers from the 3rd and 5th grades and another with those from the 6th to 9th grades. The interview script can be found in Chart 3. These interviews were conducted after the school activities, recorded, and subsequently transcribed.

2.4. Data analysis

Objective questionnaire data were analyzed using descriptive statistics in Excel. Open-ended responses ("Why do you believe the project deserves that grade?" and "Talk about the knowledge that the project activities brought to you") and interview transcriptions were processed using the IRAMUTEQ 0.7 alpha 2 software (*Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires*). For this, we created three textual *corpus*: (1) students' justifications for the project grade, (2) students' perceptions of the knowledge gained from project activities, and (3) interview transcriptions. These *corpus* underwent similarity analysis, leveraging graph theory to discern word co-occurrences and their connectivity (Camargo and Justo, 2013). The

1) What grade would you give to the activities proposed by the "*Onda Cultural nas Escolas*" project?
   a) 1 (did not like anything) ( )
   b) 2 (did not like almost anything) ( )
   c) 3 (liked almost everything) ( )
   d) 4 (gostei de quase tudo) ( )
   e) 5 (liked everything) ( )

2) Why do you believe the project deserves that grade?

3) Which activities did you like the most?
   a) Classes ( )
   b) Experiences ( )
   c) Reading circles ( )
   d) Field trips ( )

4) Do you believe you learned something from these activities?

   Yes ( ) No ( )

5) Talk about the knowledge that the activities of the project brought to you.

6) Mark the field trips you participated in:
   a) Itaipu Beach and Itaipu Archaeological Museum ( )
   b) Boa Viagem Beach and Janete Costa Museum ( )
   c) Darwin's Path Trail and Itaocaia Farm ( )

7) Did you like the field trip? Why?

8) What did you like the LEAST about your field trip? Why?

9) What did you like the MOST about your field trip? Why?

10) Leave a comment for the teachers and monitors who brought the "*Onda Cultural nas Escolas*" to your school.

Chart 2. Questionnaire administered to 6th to 9th-grade students.

1) Did the "*Onda Cultural nas Escolas*" project achieve its fundamental goal of enriching the teaching and learning process while enhancing the application of oceanic culture and heritage education in the school curriculum? Why or why not?

2) How do you assess the various teaching strategies used in the "*Onda Cultural nas Escolas*" project?

   a) Lecture lesson.
   b) Hands-on and experimental lesson.
   c) Reading circle.
   d) Field trip.

3) What are your thoughts on:

   a) The content provided for the lessons?
   b) The way the activities were organized?
   c) The interaction between the project Professors, interns, students, and the schoolteachers?

4) In your opinion, what was the strongest aspect of the "*Onda Cultural nas Escolas*" project?

5) In your opinion, what was the weakest aspect of the "*Onda Cultural nas Escolas*" project?

6) Do you have any suggestions, criticisms, or compliments for the next implementation of the project in the schools of the municipal education network in Niterói?

Chart 3. Script of the interview applied to partner teachers of the project.

outcomes display words in varying sizes linked by branches of different thicknesses (Salvador et al., 2017). Larger words denote central nodes, while branch thickness indicates connectivity strength (Camargo and Justo, 2013).

2.5. Ethical procedures

The study complied with Resolution No. 510 from 2016 (Brasil, 2016) and received approval from the Research Ethics Committee of the Federal Fluminense University (Approval No. 4,889,994). Written informed consent was obtained from the legal guardians of participating students, whereas partner teachers also provided their consent by signing the respective forms.

3. Results

Six of the seven Ocean Literacy (OL) principles and 32 of its 45 concepts were incorporated into the activities; however, the seventh principle, “The ocean is largely unexplored,” was not directly addressed. It was touched upon through students' remarks such as, “Only 5% of the ocean is known,” and questions like, “Is it true that we know more about space than the ocean?”

Furthermore, the activities embraced seven of the ten dimensions proposed by McKinley et al. (2023). All initiatives centered on content

Fig. 1. Activities developed in the project. A: Cultural, historical, and natural heritage of Niterói city; B: Litter in natural heritage sites; C: Marine and coastal organisms; D: Field trip to Itaipu Lagoon, Itaipu Beach, and Itaipu Archaeological Museum; E: Observation of biological material and litter in the natural environment; F: Reading circle; G: Field trip to Boa Viagem Beach, Contemporary Art Museum, and Janete Costa Museum of Popular Art; H: Decomposition bottles; I: Ocean acidification; J: Field trip to Darwin's Paths Trail and Itaocaia Farm; K: Formation and diversity of sediments; L: Seawater properties.

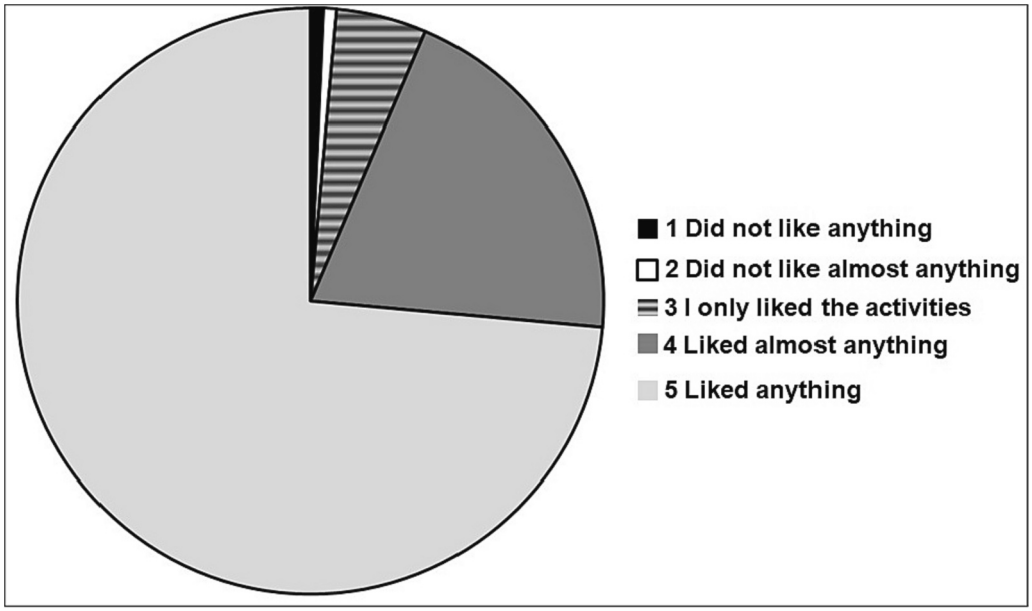

Fig. 2. Students' responses to the question "What score would you give to the developed activities?"

related to the ocean and marine environments, encompassing the "knowledge" and "awareness" dimensions. The "behaviour" dimension emerged prominently in discussions about litter and during field trips, with noticeable shifts in students' perceptions and actions concerning beach litter. The dimensions of "activism" and "attitude" manifested in actions like fifth-grade students crafting recycling posters for the school. Field trips, such as beach cleanups, were highlighted by several students as favorites, with comments like, "I enjoyed collecting litter because it helped marine animals." The field trips emphasized the dimensions of "access and experience" and "emotional connection." However, the dimensions of "communication," "adaptive capacity," and "trust and transparency" were not explicitly covered. While McKinley et al. (2023) argue that ideally all dimensions should be addressed for a holistic understanding of OL, the scope of our activities, defined in collaboration with partner teachers, did not accommodate all dimensions.

Different teaching strategies enriched the activities. Lecture sessions introduced topics, experimental activities promoted hands-on exploration, reading circles encouraged critical discourse on marine issues, and field trips bridged students to their city's natural and cultural spaces. Fig. 1 showcases images from the activities which were previously

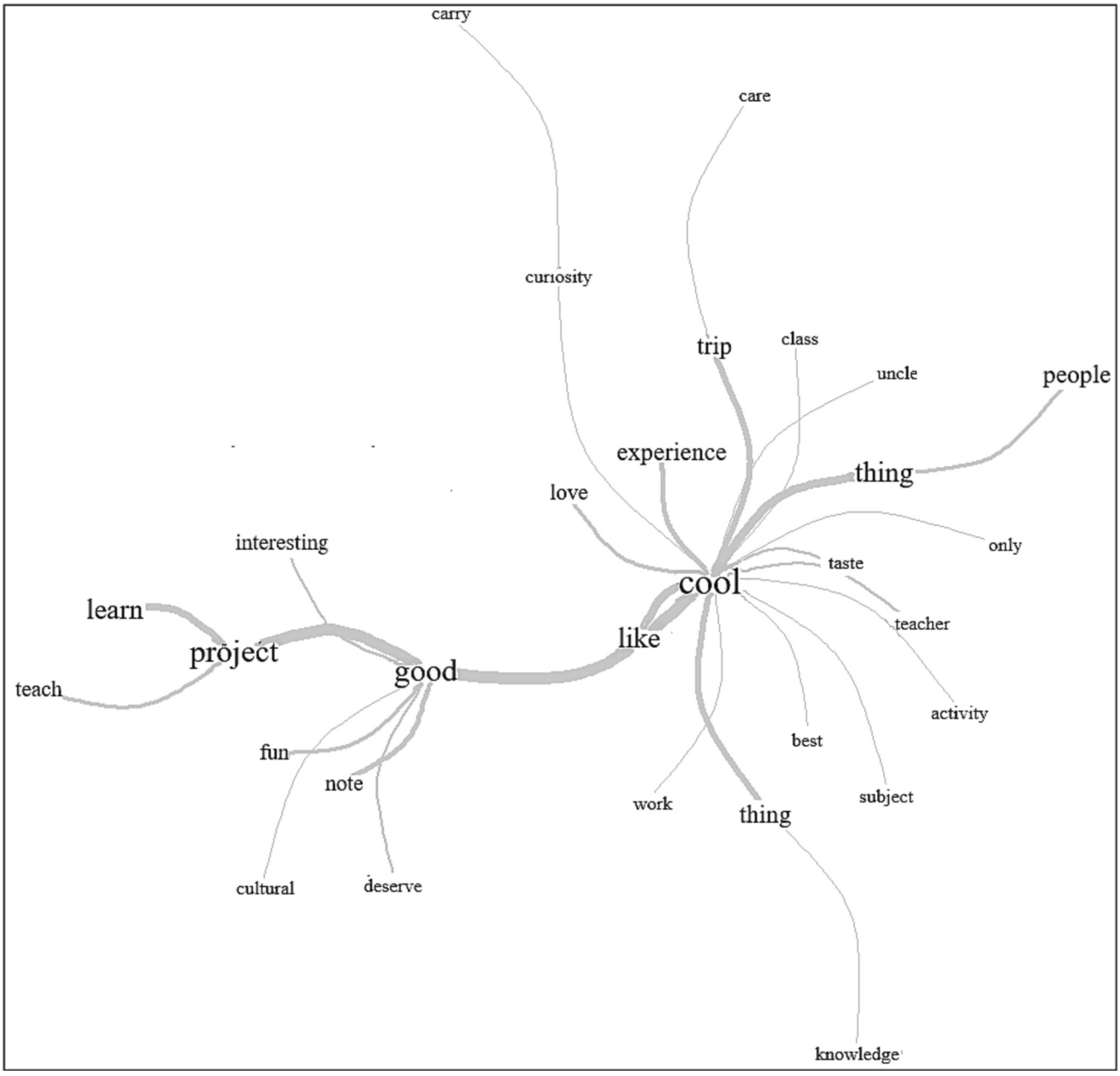

Fig. 3. Similarity analysis for the student survey question, "Why do the project activities deserve this grade?".

detailed in Material and Methods (Table 3) for objectives, duration, and number of teachers and classes involved.

Of the 235 students who participated in the project activities, 141 provided feedback through the questionnaire designed to infer students and school teachers' perceptions on the effectiveness of the activities. The results bring information on several sensitizations of children toward different Ocean Literacy dimensions. A convincing 73 % of these respondents awarded the project the top rating, as depicted in Fig. 2. This positive feedback was consistent with the researchers' own observations and reflections during the project's course. Evidently, the initiative had a tangible impact, with students actively engaging and resonating with the experiences. Some notable comments captured in the field notebook include: "The outings and activities were incredible;" "I loved the activities;" and "I learned several things about the sea and also various interesting facts."

The similarity analysis of students' responses to the question "Why do you believe the project activities deserve this grade?" can be seen in Fig. 3. The central words in the graph are "good," "enjoyable," and "project." Branching from "enjoyable" are terms like "experience," "curiosity," "topic," "activity," "trip," "lesson," and "teacher." The word "good" links to "fun" and "cultural." Meanwhile, "project" is associated with "teach," "learn," and "interesting." In essence, students' favorable ratings of the project were based on their enjoyment of the activities, as indicated by terms such as "experience," "trip," and "fun," the subject matter ("topic," "curiosity," "interesting"), and the knowledge they gained from the lessons ("teach," "learn").

When asked, "Which activities did you enjoy the most?", students had the freedom to choose multiple activities. Notably, field trips and experimental tasks were the top choices, as depicted in Fig. 4. Regardless, they actively participated in all the activities put forth. In lecture-based sessions, students regularly posed questions relevant to the discussed topics and relayed personal experiences tied to those subjects. Interestingly, 3rd and 5th-grade students displayed higher engagement levels during these lectures compared to the 6th, 7th, and 9th graders. The latter group showed signs of restlessness, especially when activities extended over two class periods.

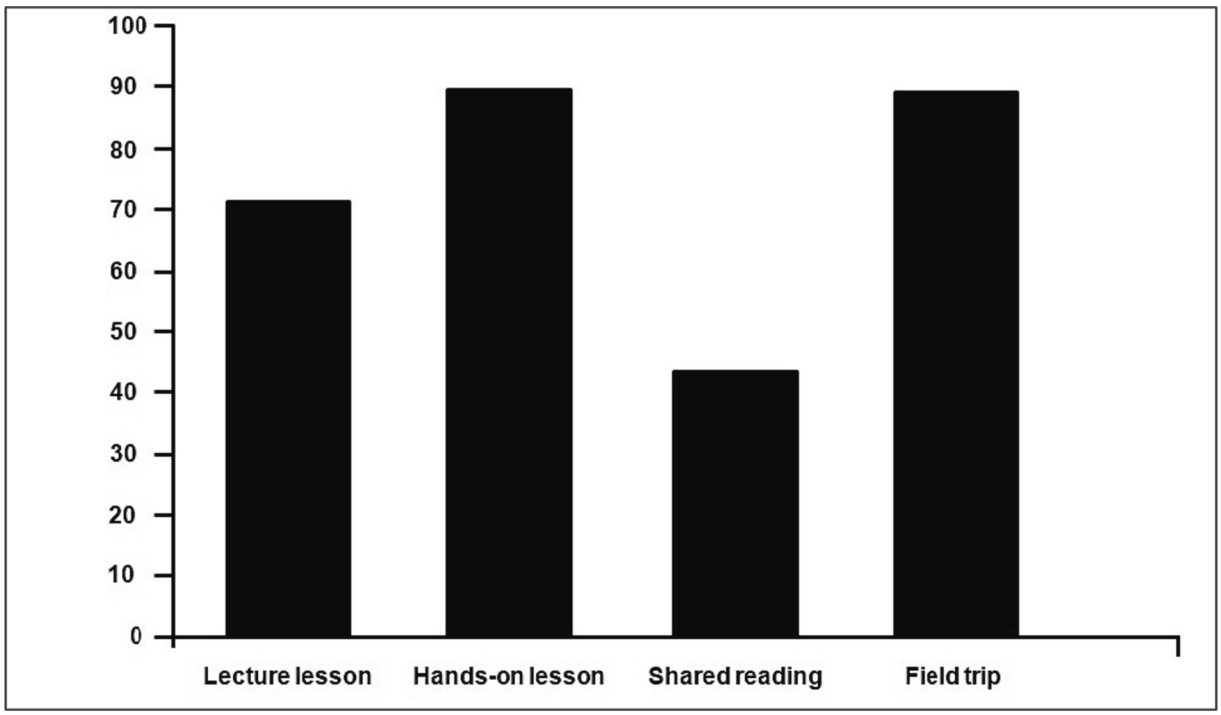

Fig. 4. Students' responses to the question "Which activities did you enjoy the most?".

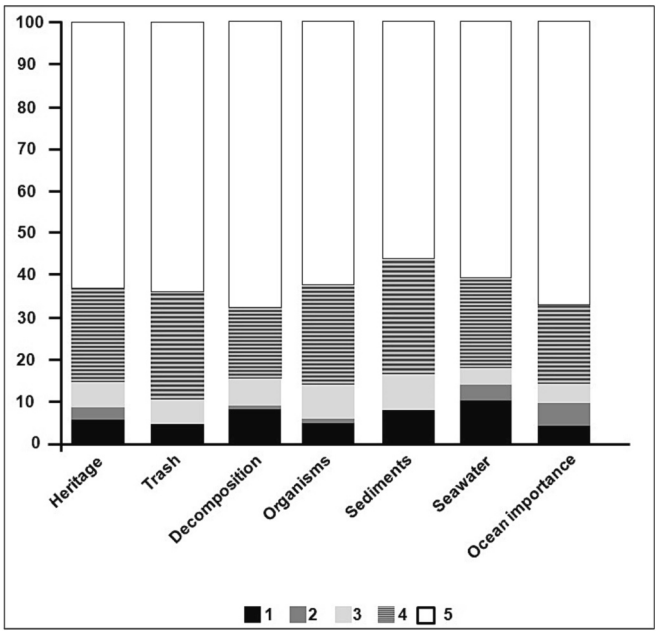

Fig. 5. Perception of 5th-grade students regarding their learning from the different topics covered in the activities (from 1 [did not learn anything] to 5 [learned a lot]).

A significant majority of the students, 92 %, believed that the classroom activities enriched their learning, as represented in Fig. 5. The similarity analysis of the responses from the 6th to 9th-grade students to the question, "Discuss the knowledge the project activities brought to you", is depicted in Fig. 6. At the core of the graph are the words "knowledge," "experience," "bring," and "animal." The term "knowledge" is closely associated with "environment," "sea," and "nature." The word "experience" links to "learn," "know," and "beach." Concurrently, "bring" is connected to "outing" and "field," and "animal" is related to "know." These associations suggest that students largely credit their learning to hands-on activities and field trips. Moreover, they feel they gained substantial knowledge about the sea, beach, environment, nature, and animals.

Fig. 7 presents the similarity analysis of the textual *corpus* stemming from the focus group interviews with partner teachers, which expands the inferences done by the researchers in relation to the effectiveness of activities in bringing to children sensitization toward the different dimensions of Ocean Literacy. Central to the graph are the terms "stay," "think," "project," "be," "class," and "people." From the teachers' insights, the executed activities received positive feedback. Their commendations stem from: (1) demonstrated student interest, evident from words such as "want," "like," and "participate" that associate with the term "stay;" (2) the significance and relatability of the subjects addressed, highlighted by terms like "reality," "child," "knowledge," and "important" that tie into "project;" (3) the observable student engagement, underscored by words like "engagement," "public," and "positive," linked to "think;" (4) the variety of instructional strategies employed, represented by "lecture," "work," and "hands-on" that correlate with "class;" (5) the shift in students' understanding of natural settings, denoted by "content," "beach," and "notion" that relate to "be;" and (6) the revitalization of the school milieu and the strengthening bond between the school and the university, signified by terms like "school," "trip," "dynamic," "school environment," "university," "relationship," and "involve," which are connected to "people."

4. Discussion

Content related to oceans and marine environments is often underrepresented or entirely omitted from school curricula (Chang et al., 2021; Mokos et al., 2021; Pazoto et al., 2021; McPherson et al., 2018a; Gough, 2017; Castle et al., 2010). Consequently, incorporating these themes into classrooms can be challenging (Freitas et al., 2022; McPherson et al., 2018b; Castle et al., 2010). To address this educational gap for children and teenagers, there is a need for activity proposals that emphasize Ocean Literacy (OL) principles. To do so, collaborative efforts between research centers, universities, specialists, and schools are

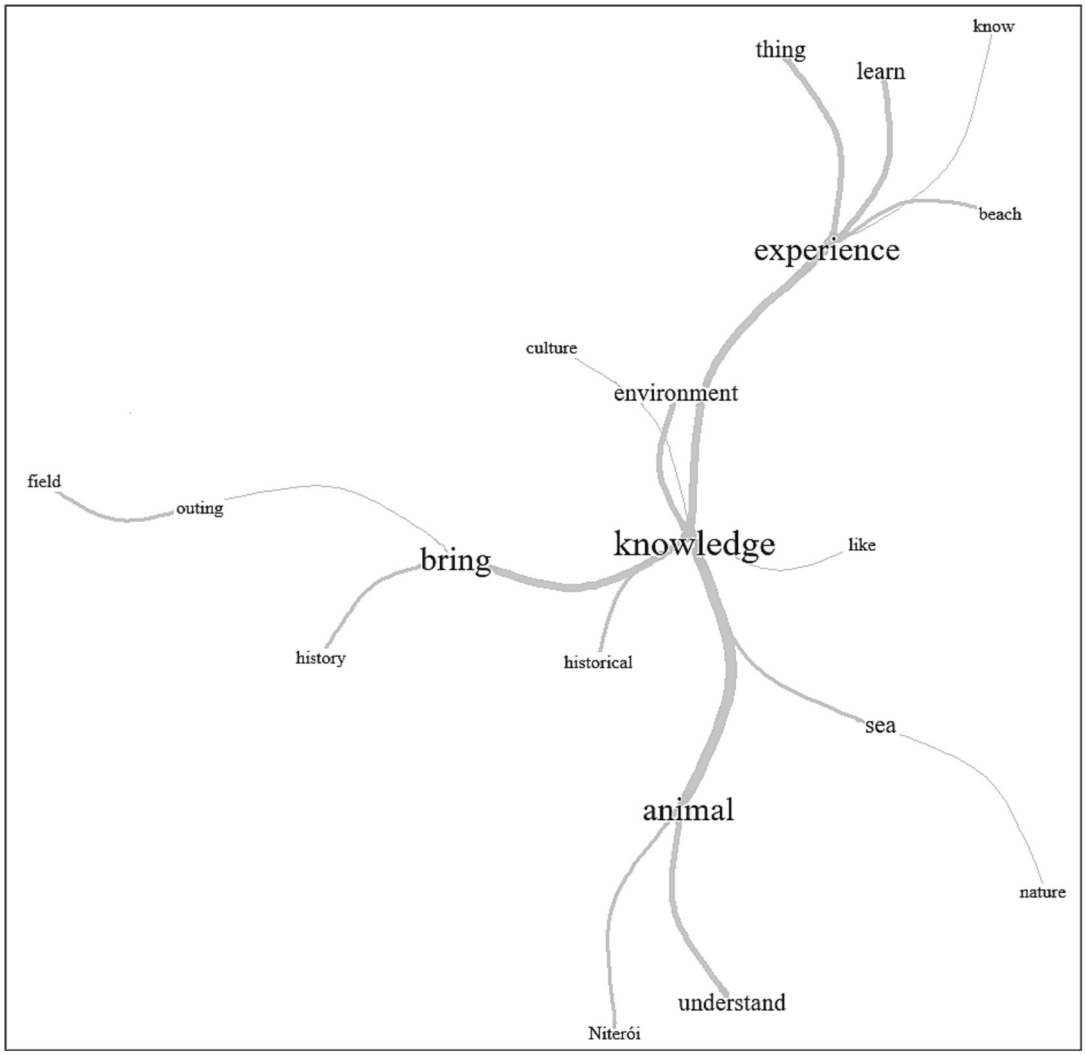

Fig. 6. Similarity analysis of responses from students in the 6th, 7th, and 9th grades to the question: "Discuss the knowledge the project activities brought to you".

essential (Cheimonopoulou et al., 2022). This study exemplifies such collaboration, highlighting a partnership between university and school to conduct OL-focused activities for students aged 8 to 15. Local natural and cultural heritage sites were used as teaching tools in this study.

The activities designed in this study covered six OL principles, deliberately excluding the 7th principle, "The ocean is largely unexplored." Not all studies that incorporate OL-based projects or activities in formal and informal settings encompass all principles. Principles 5 (about marine life) and 6 (concerning human-ocean relationships) are more frequently addressed. For example, Boaventura et al. (2021) designed activities for Portuguese children aged 9 to 11 that included these principles. Similarly, Mokos et al. (2020) outlined activities for a European Maritime Day workshop in Croatia that addressed ocean acidification (principle 3), marine biodiversity and food chains (principle 5), and overfishing (principle 6). Riedinger and Taylor (2019) discussed a four-day U.S. field trip program for middle schoolers that included principles 1, 2, 5, and 6.

More than just introducing principles and concepts, this initiative sought to embed OL dimensions into the activities, recognizing their potential to impact ocean literacy levels (Stoll-Kleemann, 2019). While efforts to integrate these dimensions into OL research are still emerging (McKinley et al., 2023), this project breaks new ground by formally aligning them with OL activities in formal education. The "knowledge" and "awareness" dimensions were particularly impactful for students. This outcome aligns with other OL action research (e.g., Stefanelli-Silva et al., 2019; Plankis and Marrero, 2010). These dimensions were emphasized because they align closely with the curriculum and teachers' interests.

Students also responded positively to the "behaviour," "attitude," and "activism" dimensions, as evidenced by questionnaire responses, which reflect the perceptions of children in relation to the activities, and also by in-class feedback. For instance, students participated in beach cleanup efforts. After a similar intervention, Hartley et al. (2015) found that British children aged 8 to 13 recognized the detrimental effects of waste on marine ecosystems and took actions to reduce marine litter. Moreover, students were motivated to prompt their peers to adopt pro-environmental behaviors ("activism"), such as creating posters advocating recycling.

Field trips were highly valued, playing a significant role in students' learning. Engaging directly with natural environments enhances learning, fostering emotional connections and developing hands-on and observational skills that classroom settings cannot replicate (Barracosa et al., 2019; Dupont and Fauville, 2017). Field activities predominantly fostered "access and experience" and "emotional connection" dimensions. As seen by Mioni (2022), hands-on nature experiences significantly boosted student interest in marine issues. Although field activities present challenges (like lack of financial resources, school staff support, and time to prepare activities), they offer unparalleled learning experiences, making them invaluable for enhancing students' OL (Dupont and Fauville, 2017).

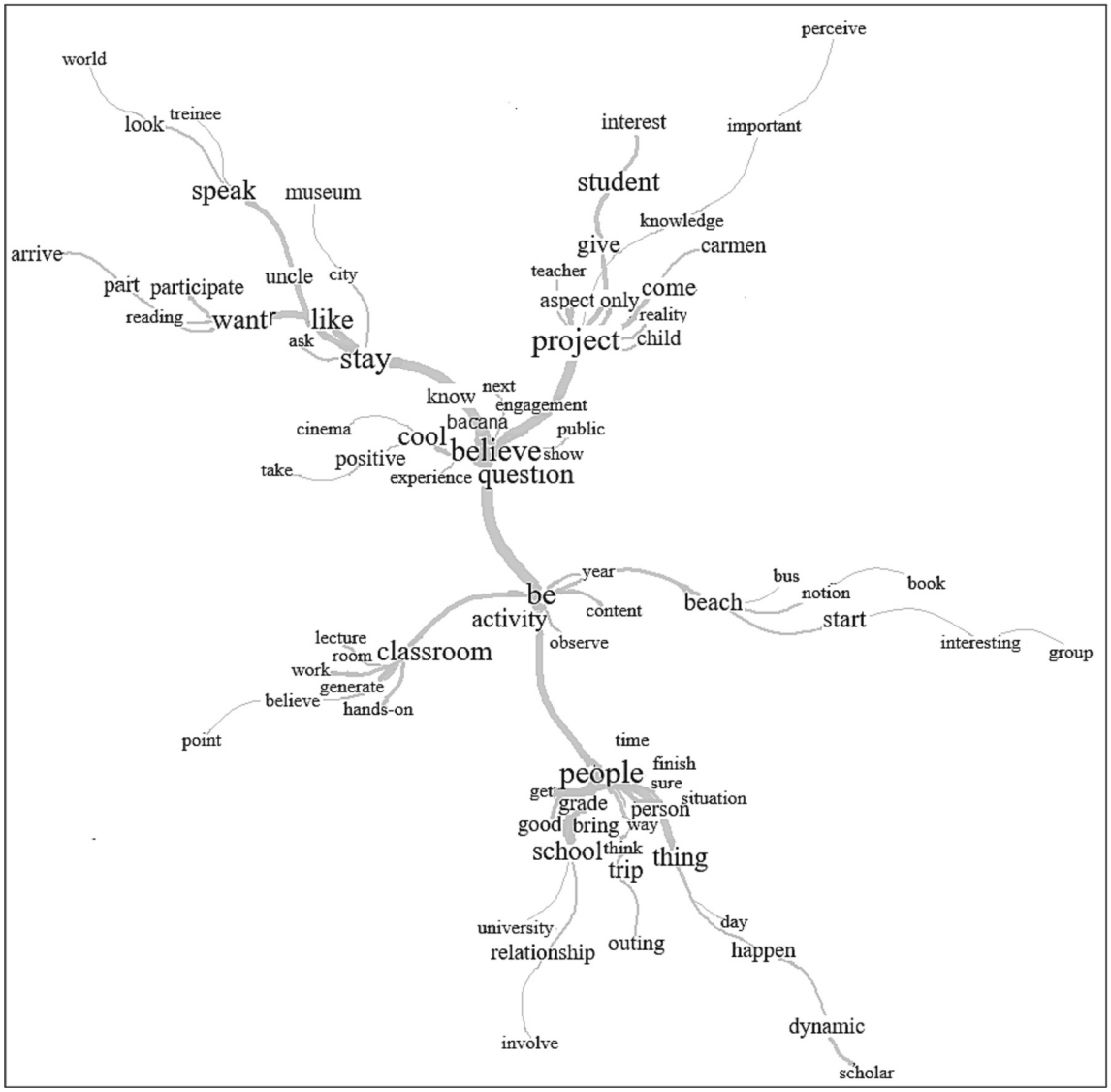

Fig. 7. Similarity analysis for the focus group interview with partner teachers.

Ocean-related knowledge is often linked to science and geography curricula (Payne and Marrero, 2021; Gough, 2017). However, oceans represent an interdisciplinary theme, offering a vast field for educators across subjects (IOC-UNESCO, 2022; Ghilardi-Lopes et al., 2019; Santoro et al., 2017). This project successfully showcased the interdisciplinary nature of OL, as it established partnerships with teachers from various subjects other than science. Roughly 20 % of the teaching staff participated, a figure consistent with the literature. For example, in a study by Santos et al. (2018), seven of 39 teachers from a coastal public school in São Paulo, Brazil, engaged in coastal environmental education activities. Partner teachers in this study praised the year-long activities; in their perception the project was able to captivate students with various teaching methods, enriching the learning environment and promoting school-university partnerships.

Research on OL in education is sparse but essential (Payne and Marrero, 2021). Despite challenges in implementing school studies (like aligning with teacher schedules), schools remain the primary institutions for educating the youth (Freitas et al., 2022; Ferreira et al., 2021). In this context, this study contributes to the limited body of OL research in formal education settings. It expanded the dimensions, principles, and concepts of OL among students and involved teachers in a topic often sidelined in school curricula. Furthermore, the program developed and applied in this study can be adapted to other regions of Brazil, since worked subjects on marine environments developed in the activities are in line with the contents defined in Brazilian curricular guidelines, as well as can be adapted to other regions of the world, since OL principles and concepts are global and a lack of issues related to them in school environments has been reported for different countries (Chang et al., 2021; Mokos et al., 2021; McPherson et al., 2018a; Gough, 2017; Castle et al., 2010).

5. Conclusion

Expanding the public understanding of the intricacies of oceanic and marine ecosystems- and the issues contributing to their degradation- is vital. It equips society to partake in initiatives that bolster the health, resilience, and sustainability of these invaluable ecosystems. As such, rolling out projects designed to deepen the knowledge and dimensions of Ocean Literacy is imperative to achieve these goals. This becomes especially salient when we consider interventions aimed at the young, our future decision-makers tasked with preserving the world's oceans.

In this vein, our study melded a variety of instructional methods (theoretical, laboratory, and fieldwork) to captivate students aged 8 to 15 from a public school in Niterói, Rio de Janeiro State, Brazil. To

achieve this, the historical, cultural, and natural heritage of the students' hometown was used to strengthen their connection to local environmental issues, while also incorporating the developed content into the school curriculum. Moreover, these undertakings were orchestrated in close collaboration with the school's teaching staff.

The students gave positive feedback on the project's activities, especially those that involved laboratory work and field trips. They also felt that these activities deepened their grasp of the topics covered. In the same vein, the partner teachers appreciated the proposed lessons, highlighting the importance of the subjects tackled and remarking that these activities invigorated the usual school routine, making the environment more dynamic. Beyond merely "knowledge" and "awareness," the activities effectively cultivated other OL dimensions such as "behaviour," "attitude," "activism," "emotional connection," and "access and experience." Thus, the intervention suggested here adds to educational research in the OL field and can be extended to other target groups and regions, aiming for a society more mindful of its use of the ocean and marine environments.

CRediT authorship contribution statement

CEP contributed to data collection, EPS contributed to study concept and design, MRD contributed to data analysis. All contributed equally to interpretation, manuscript preparation, critical revision, and adding intellectual content.

Declaration of competing interest

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.

Data availability

Data will be made available on request.

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