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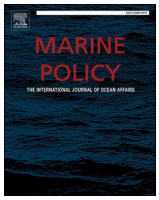

Challenges and prospects for teaching ocean literacy in Brazilian schools

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ABSTRACT

This study took as a case study the perspective of teachers working in the State of Rio de Janeiro by 53 interviews to investigate the challenges and prospects of including content about the ocean in Brazilian school classrooms. The data were subjected to content analysis and explored quantitatively using Descending Hierarchical Classification (DHC) and Factor Correspondence Analysis (FCA) of word and terms used by teachers in their discourse. The main difficulties reported in including themes related to the ocean and marine environments in classes were the absence of OL in the school curriculum and university education, as well as the limited time to work on these subjects in classes, which is in line with the challenges faced by teachers from other countries. On the other hand, Brazilian teachers cited particular problems of Brazilian formal education, such as the need for professional development, support for an education with an interdisciplinary emphasis, and provision of financial resources for schools. However, DHC analysis also indicates strong connection of the teachers with the ocean due to sea fascination (24% of the answers in the textual corpus), spiritual and emotional connection (26.7%), leisure (22.7%) and professional interest (26.7%). Furthermore, the textual corpus also identified that teachers recognize the importance of teaching marine topics due to: students live in coastal areas (32.2%), the provision of ecosystem services (19.9%), preservation issues (34.2%), and limited student knowledge on these themes (13.7%). These data can help formulate educational policies to mitigate OL teaching barriers in Brazilian schools.

1. Introduction

The global ocean corresponds to 97% of the hydrosphere, covering approximately 71% of the Earth's surface (361 million square kilometers). It is intrinsically related to human well-being, providing resources such as oxygen and food, serving as a means of trade and transportation, generating jobs, and regulating the climate, among other benefits [1,2]. However, public knowledge about the importance of the ocean is low, as indicated by several studies [e.g., [3–6].

The lack of knowledge regarding how the ocean affects human life and vice versa [7] has contributed to boost anthropogenic impacts on this ecosystem. These impacts have become increasingly severe and dramatic since the 20th century [8,9] and are expected to escalate with the expansion of the human population and its migration to coastal areas [10]. Increasing degradation has imposed the need for conservation and restoration of the ocean and demanded policies for the sustainable use of its resources. Therefore, the period between 2021 and 2030 has been designated by the United Nations as the Decade of Ocean Science for Sustainable Development (Ocean Decade).

One of the significant challenges of the Ocean Decade is to mobilize civil society in making decisions about the use of the ocean and its resources, which necessitates an increase in public understanding of the ocean and its ecosystems. Citizens educated about the problems and possible solutions related to marine issues are expected to make choices that reduce the impact on these environments [11,12]. In this regard, an education that includes marine and ocean themes plays a key role in promoting knowledge and awareness about the importance of the ocean for life on Earth and its vulnerability [13,14]. The campaign for Ocean Literacy (OL) is an initiative that has promoted ocean knowledge and encourages social participation in the actions of the Ocean Decade [15].

Emerging in the early 2000s in the United States from the perception that the knowledge of the American population about the ocean was scarce, in addition to the fact that the presence of the ocean themes in the school curriculum was deficient [16], OL means that students, at the end of the school term, should be able to (1) understand fundamental concepts about how the ocean works, (2) speak in an informed manner about issues related to the marine environment, and (3) make informed and responsible decisions about the ocean and its resources [17]. Thus, its target audience should be children and young people of school age, as they will be the decision-makers in the future [15]. Therefore, the school

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is a privileged place where OL should be developed [7,18].

Including OL in formal education is still a challenge, especially given the current composition of school curricula [19–25]. However, apart from integrating OL into the curriculum, including these themes in classrooms relies on the teacher's role as a mediator of content [26,27]. For this reason, several studies have investigated teachers' perceptions of their teaching practices regarding the ocean theme. For instance, Castle et al. [20] interviewed teachers in the county of Dorset, England, and identified limited class time, the absence of these themes in the curriculum, and the lack of teaching resources as the primary barriers to teaching marine sciences. The same results were repeated in interviews with high school teachers in Nova Scotia, Canada [28]. Eidietis & Jewkes [29] used questionnaires administered to teachers in 10 US states and identified that most research participants had positive attitudes towards ocean science but felt unprepared to teach these contents. Freitas et al. [30] also worked with questionnaires and identified that the availability of educational resources, professional training, and support of specialists were demands of primary school teachers in Australia to facilitate the inclusion of ocean themes in their classes. However, research of this nature does not exist so far in countries of the global south. In this regard, this research aims to study the challenges and prospects of teaching about the ocean in Brazil as perceived by elementary and high school teachers, as well as their perceptions about OL as defined by its principles and concepts. The outcomes of this study are expected to foster OL in classrooms, thereby providing support for the initiatives implemented to advance the objectives of the Ocean Decade in Brazil [15].

2. Material and methods

2.1. Data collection instrument

A semi-structured interview script was developed to explore the perspectives of primary and secondary school teachers regarding the significance of teaching topics related to the marine environment, as well as the potential opportunities and obstacles associated with this form of education. The script underwent evaluation in a pilot study involving a sample of six teachers specializing in Biology, Science, Geography, and History. The obtained results were used to refine the wording and sequence of questions to enhance the clarity and comprehensibility of the script for the interviewees. The final interview script consisted of 16 questions, grouped into three sections: (1) profile of the interviewee and connection with the marine environment – encompassed questions 1–3, intending to collect sociodemographic information and the relationship between respondents and the marine environments; (2) professional trajectory – consisting of questions 4–9, whose purpose was to obtain data on the interviewees' education, their professional lives, and their familiarity with content related to the ocean theme; and (3) perception on the teaching of content about the ocean and marine environments – formed by questions 10–16, aimed to seek information on the perception of the interviewed teachers about their approach in class, the importance, challenges, and prospects of the inclusion of ocean and marine themes in the classes, as well as getting to know the ocean literacy. Chart 1 shows the interview script with the question specifications.

The selection of interviewees occurred in two stages. Initially, the research was promoted through the authors' social media platforms (Facebook and Instagram) and by sharing messages in WhatsApp groups focused on education, in which the authors were members. In a subsequent phase, the interviewed participants were requested to suggest other teachers who could potentially participate in the study. Those interested in participating in the study must meet two criteria: teach in schools located in one or more municipalities on the coast of the State of Rio de Janeiro and be a teacher of Biology, Science, Geography, or History, as a previous study indicated that these subjects were those that most presented content related to the ocean and marine environments in the Brazilian school curriculum [31].

The interviews were individual and previously scheduled according to the day and time availability of each participant. The interviews were conducted from September to December 2021 using the virtual and free Google Meet platform, mainly because all of them took place during the COVID-19 pandemic. Each interview was audio-recorded and then transcribed. The average duration of the interviews was 28 min.

Chart 1
Interview script.

#	QUESTION
1	How old are you?
2	What city do you reside in? Is it a coastal city? Have you ever lived in a landlocked city?
3	Do you have a personal connection or affinity towards the ocean and marine environments?
	a If yes, how?
	b If not, why?
4	Which undergraduate course did you graduate from, and from which institution?
5	In which municipalities do you teach? Are these municipalities located on the coast?
6	What subjects do you teach, and in which teaching segments?
7	How long have you been a teacher?
8	Did you pursue any courses or subjects related to the ocean and marine environments during or after completing graduation?
9	How would you characterize your knowledge regarding the ocean and marine environments?
10	Do you believe that content related to the ocean and marine environments is significant for student education? Why?
11	Do you perceive a connection between the discipline you teach and the ocean and marine environments?
	a If yes, how?
	b If not, why?
12	Do you typically cover topics related to the ocean and marine environments in your classes? If so, how do you approach and incorporate those subjects?
13	How do you evaluate the presence of content related to the ocean and marine environments in the school curriculum of your subject?
	a If this content is included, do you believe that the curriculum approach alone is adequate to cultivate basic knowledge about the ocean and marine environments in students?
14	From your perspective, what are the primary factors that impose the greatest limitations on incorporating content related to the ocean and marine environments into your subject?
15	In your opinion, what would it take for you to include this content in your subject's classes?
16	Have you ever heard of Ocean Culture or Ocean Literacy? If yes, what do you think it would be?

2.2. Data analysis

The sociodemographic information of participants, including age, gender, teaching segment, subject taught, professional training related to the marine theme, years of professional experience, place of residence in proximity to the coastal region, and their familiarity with Ocean Literacy (OL), was tabulated and analyzed using descriptive statistics in Microsoft Excel.

Systematization and categorization of answers referring to the teacher's knowledge and the way of approaching the classes regarding the contents of the ocean and marine environments, the presence of these themes in the school curriculum, and the challenges and prospects for the inclusion of these themes in the classes were analyzed using the content analysis technique [32]. The interview transcripts underwent the following procedure: (1) initial reading to familiarize with the material (pre-analysis phase); (2) identification and definition of analysis categories based on the reading (material exploration phase); (3) coding of registration units (which are correspondent to the perception of the interviewees about the themes categorized), defined by the context units which are excerpts of teacher's answers that gives the meaning of the registration units categorized and submitted to a frequency counting;

and (4) treatment of results, inference, and interpretation conducted during the final phase of content analysis.

The software IRAMUTEQ 0.7 alpha 2 (Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires), which informs the relationships between the words most frequently enunciated by the individual, was used to understand the structure and organization of the teachers' answers relative to their (1) connection with the marine environment and (2) perception of the importance of teaching content about the ocean to students. This software necessitates the preparation of a textual corpus, which comprises a collection of texts centered around a specific subject. In this study, each text in the corpus represented the response of an interviewee. Two textual corpora were constructed and corresponded to (1) the relationship of the interviewed teacher with the marine environment and (2) the perception of the importance of teaching content about the ocean and marine environments for student training. The two textual corpora underwent descending hierarchical classification (DHC) analysis. In this technique, each respondent's response to the question being analyzed begins with an initial context unit. From there, textual segments are identified and classified, ensuring that each class of text segments shares a similar vocabulary and differs from the text segments of other classes [33]. The result is organized in the form of a dendrogram, which visually represents the relationships between the different classes. The dendrogram also shows a list of words significantly associated with each class ($p < 0.05$). The statistical significance of this association was verified using the chi-square test [34]. Factorial correspondence analysis (FCA) was employed to visualize the proximity between classes [34].

3. Results

A total of 53 teachers were interviewed, all of whom taught in 10 coastal municipalities in the state of Rio de Janeiro. Only two interviewees did not reside in coastal cities at the time of the interview, and 12 were born and raised in non-coastal cities. Additionally, two interviewees taught in both coastal and non-coastal municipalities. The majority of the interviewees (58.5%) had previous exposure to content related to the ocean and marine environments during their professional training. Among those who had no such exposure, most were History teachers (10 out of 11 History teachers). The age of the interviewees ranged from 28 to 67 years, with an average age of 42. They had been working in the teaching profession for a duration ranging from 4 to 40 years, with an average of 16 years. The interviewed teachers were primarily employed in the public school system (69.8%), which accounts for 58% of educational institutions in the state of Rio de Janeiro [35]. They taught in both elementary and high school education levels (45.3%). Additionally, only 10 respondents had prior contact with OL. These details are summarized in Table 1.

Out of the 53 interviewed teachers, four indicated that they did not incorporate content about the ocean and marine environments into their classes. However, the majority of teachers mentioned including these subjects, albeit to a limited extent. The content analysis revealed that Biology and Science teachers presented the ocean theme in the context of biodiversity and environmental issues, while Geography teachers focused on aspects such as relief, ocean use, and occupation, such as economic, social and cultural activities in which different human communities in their practice use this space. History teachers highlighted the ocean and marine environment as spaces for culture, commerce, and transportation. Only four teachers considered the presence of ocean-related content in the school curriculum to be satisfactory, while most respondents viewed it as a limited theme within the curriculum (N = 35). In relation to the perception of knowledge that each interviewee has on topics related to the ocean, four categories emerged: sufficient (presents adequate knowledge on the topic); median (presents knowledge on the topic); limited (presents little knowledge on the topic); and insufficient (presents knowledge on the topic which would not be enough to take the topic to their classes). Among these categories, only one teacher expressed a perception of insufficient knowledge of the ocean and marine environments, while the majority regarded their knowledge as limited (N = 26). These findings are summarized in Table 2.

Table 1
Characterization of the interviewed teachers relative to the sociodemographic profile, training relative to the marine environment, professional activity, and contact with Ocean Literacy (N = 53 interviewed teachers).

Interviewee's profile	Classification	N (%)
Gender	Male	36 (68%)
	Female	17 (32%)
Residence	City with coastline	47 (88.7%)
	Landlocked city	6 (11.3%)
Age	20–30 years	3 (5.7%)
	31–40 years	22 (41.5%)
	41–50 years	21 (39.6%)
	51–60 years	5 (9.4%)
	61–70 years	2 (3.8%)
Did you take a course on the marine environment?	Yes	31 (58.5%)
	No	22 (41.5%)
Teaching time	1–10 years	14 (26.4%)
	11–20 years	24 (45.3%)
	21–30 years	12 (22.6%)
	31–40 years	3 (5.7%)
Subject	Biology	9 (20%)
	Sciences	8 (15.1%)
	Sciences and Biology	7 (14.2%)
	Geography	18 (34%)
	History	11 (20.7%)
Education segment	Elementary	16 (30.2%)
	High	13 (24.5%)
	Elementary and high	24 (45.3%)
Education system	Private	7 (13.2%)
	Public	37 (69.8%)
	Private and public	9 (17%)
Contact with Ocean Literacy	Yes	10 (18.9%)
	No	43 (81.1%)

A correlation analysis conducted between the data on the perception of knowledge and content approach in Table 2 revealed a weak positive correlation ($R = 0.301$), yet highly significant ($p = 9.23 \times 10^{-8}$) between these data.

The responses from teachers regarding the factors that hinder the inclusion of content related to the ocean and marine environments in their subject classes identified a total of 107 barriers. These barriers were further analyzed and categorized into seven main themes and 22 subthemes, as outlined in Table 3. According to the teachers, the primary challenge in teaching content about the ocean and marine environments is the absence of the subject in the school curriculum (N = 20). This is followed by a lack of time to address this content (N = 13) and insufficient professional training that covers the theme (N = 11).

Regarding the strategies to overcome these barriers, the interviewees highlighted 87 factors that could facilitate the inclusion of ocean and marine themes in the classroom. These factors were further categorized into seven main themes and 25 subthemes, as presented in Table 3. Among the identified actions, two were considered crucial to address the

Table 2
Categories defined from the content analysis for the answers of teachers interviewed about the perception of their knowledge relative to contents about the ocean and marine environments, the approach of these contents in their classes, and the presence of these contents in the school curriculum. Bio = Biology; Sci = Sciences; Geo = Geography; Hist = History.

	Subject					
Knowledge perception	Bio	Sci	Bio/ Sci	Geo	Hist	N
Sufficient	5	1	3	2	0	11
Median	2	5	2	5	1	15
Limited	3	1	1	11	10	26
Insufficient	0	1	0	0	0	1
Content approach	Bio	Sci	Bio/ Sci	Geo	Hist	N
Yes	9	6	6	12	8	41
Little	1	1	0	5	1	8
Do not address	0	1	0	1	2	4
Perception of presence in the curriculum	Bio	Sci	Bio/ Sci	Geo	Hist	N
Satisfactory	3	1	1	0	1	6
Restrict	5	4	3	17	6	35
Implicit	2	3	1	1	1	8
Absent	0	1	0	0	3	4

aforementioned challenges: the inclusion of the theme in the school curriculum (N = 14) and the provision of continuing education opportunities for teachers (N = 11). According to the interviewees, these actions could help address the lack of initial professional training focused on topics related to the ocean and marine environments.

The descending hierarchical classification (DHC) analysis performed on the textual corpus pertaining to teachers' perceptions of the importance of content related to the ocean and marine environments for student education (question 10 of the interview script) resulted in the identification of four distinct classes (Fig. 1). The first class, accounting for 32.2% of the texts, consisted of statements from teachers who considered the study of ocean and marine themes important for students residing in coastal regions. Class 2 (19.9% of the texts) encompassed the perception that learning about the ocean and marine environments holds significance due to the ecosystem services associated with them. Class 3 retrieved 34.2% of the texts and emphasized the importance of raising students' awareness about ocean preservation. Lastly, Class 4 (13.7% of the texts) indicated that teachers viewed teaching content about the ocean and marine environments as important because such topics are inadequately addressed in schools and students possess limited knowledge about them. The factorial correspondence analysis (FCA) (Fig. 2) revealed that the first axis (43.35% of the total variation) distinguished class 1 from the other classes, while the second axis (30.19% of the total variation) allowed differentiation between classes 2 and 3 from class 4.

The DHC analysis conducted on the responses concerning the connection of the interviewed teachers with the marine environment (question 3 of the interview script) resulted in the identification of four classes, as illustrated in Fig. 3. Class 1 accounted for 24% of the texts and indicated a fascination with marine environments among the respondents. The second class, representing 26.7% of the texts, reflected an emotional and spiritual connection with the marine environment. The third class (22.7% of the retrieved texts) emphasized a connection related to leisure activities. Lastly, the fourth class (26.7% of the recovered texts) demonstrated an association between the interviewees and their professional involvement with marine environments. The FCA (Fig. 4) revealed that axis 1 (41.13% of the total variation) distinguished class 1 from the other classes, while axis 2 (31.94% of the total variation) allowed differentiation between class 4 and classes 2 and 3.

4. Discussion

Ocean Literacy (OL) is recognized as a crucial element for the success of the Ocean Decade, with formal education being identified as a key area for its promotion [15]. To comprehend the perspectives and challenges associated with incorporating OL into formal education, it is essential to investigate and interpret the difficulties faced by teachers in implementing these contents and the proposed solutions to overcome these barriers. Previous studies have indicated a positive correlation

Table 3
Mentioned barriers and solutions identified in the teachers' statements based on a content analysis divided into themes and subthemes. F = frequency, % = Percentage, N = Total subthemes.

	Barrier			**Solution**		
Theme	**Subtheme**	**F**	**%**	**Subtheme**	**F**	**%**
Curriculum	Absence of the content in the curriculum	20	18.7	Inclusion of the subject in the curriculum	14	16.1
	Extensive curriculum	6	5.6	Curriculum reformulation	2	2.3
	Curriculum organization	1	0.9			
Professional training	University education	11	10.3	University education	7	8.0
	Continuing education	3	2.8	Continuing education	11	12.6
Professional performance	Lack of time to prepare lessons	5	4.7	Interest in the theme	7	8.0
	Theme perceived as not relevant	4	3.7	Making the topic relevant to the subject	3	3.4
	Lack of knowledge	4	3.7	Working in an interdisciplinary way	3	3.4
	Lack of interest	4	3.7	Overcoming traditional teaching methods	3	3.4
	Preference for traditional teaching methods	2	1.9	Stimulating student interest in the theme	2	2.3
	Curriculum interpretation	2	1.9	Perception of the importance of the theme	2	2.3
				Use of technology	2	2.3
				Use of active methodologies	1	1.1
Institutional	Lack of time to address the theme	13	12.1	Longer class time	5	5.7
	Lack of interdisciplinary work	4	3.7	Encouraging interdisciplinary work	4	4.6
	Emphasis on tests	3	2.8	Professional appreciation	3	3.4
	Pressure to follow the curriculum	2	1.9	Institutional support to address the issue	2	2.3
	Remote teaching	1	0.9	Greater autonomy for the teacher	1	1.1
	Lack of technological resources	1	0.9	Reformulation of university entrance	1	1.1
				Reformulation of the school model	1	1.1
Field class	Lack of field class	3	2.8	Institutional support for field trips	3	3.4
	Lack of resources for field classes	3	2.8	Field trips	2	2.3
	Lack of parental support for field classes	1	0.9	Parent support for field trips	1	1.1
Material resources	Lack of material resources	5	4.7	Production of didactic material	5	5.7
Public Interest	Student interest	2	1.9	Develop society's interest in the theme	1	1.1
				Public fascination with the marine environment	1	1.1
N		107			87	

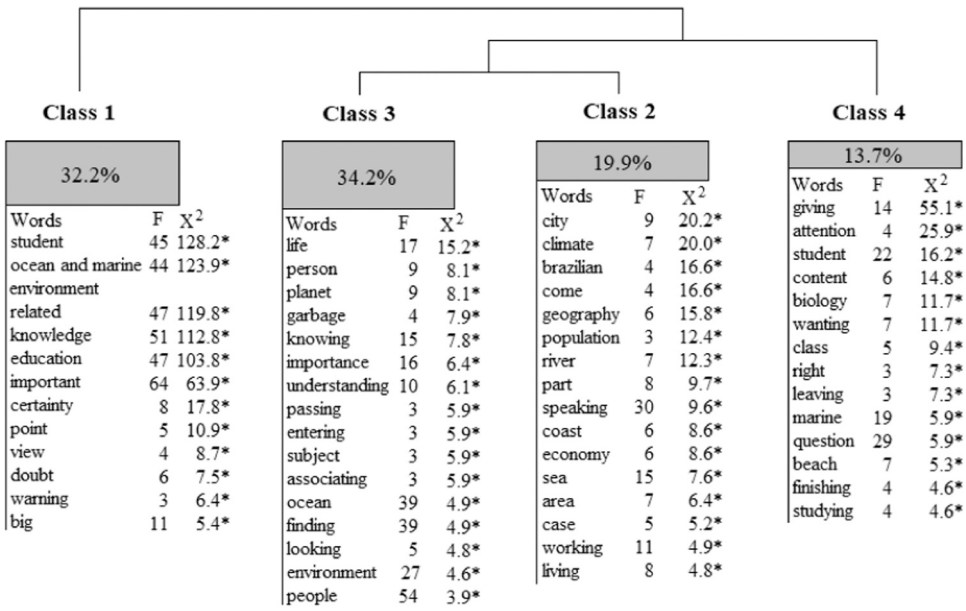

Fig. 1. Dendrogram of descending hierarchical classification of the textual corpus on the teacher's perception of the importance of contents on the ocean and marine environment for student training. F: frequency of occurrence of the words listed within each class; χ^2: chi-square test values; *significant values ($p < 0.05$).

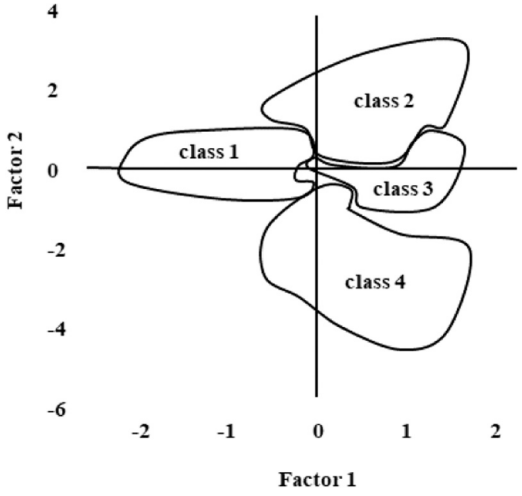

Fig. 2. Factorial correspondence analysis of the textual corpus on the teacher's perception of the importance of contents about the ocean and marine environment for student education.

between a teacher's claimed knowledge of specific content and their decision to introduce it in the classroom [26,36]. This correlation was also observed among the interviewed Brazilian teachers, who reported incorporating ocean-related subjects in their classes "when it is appropriate and there is space within the curriculum" (teacher 2), "taking advantage of gaps in certain topics of the curriculum" (teacher 49), or "seeking examples that relate to marine environments" (teacher 9).

The school curriculum plays a crucial role in determining the inclusion of OL in classrooms, as highlighted in the literature [7,37,38]. Numerous studies conducted worldwide have indicated that the presence of subjects related to the ocean and marine environments is either limited or even absent from school curricula [20–24], including the curriculum in Brazil [25,31]. In the present study, a considerable number of interviewed teachers also expressed the view that the approach to the ocean and marine themes in the Brazilian curriculum is presented in a restricted manner for all grades. Moreover, they considered the limited presence of this theme in the curriculum as the primary challenge for its inclusion in Brazilian classrooms. For instance, teacher 30 described the presence of ocean-related content in curriculum documents as "extremely poor" and emphasized that the absence of this content in the curriculum limits its inclusion, leaving it solely up to the teacher's discretion.

The lack of time to address the topic in class emerged as the second most cited barrier by the interviewed Brazilian teachers, impeding the inclusion of ocean and marine themes in schools. This constraint is intricately linked to another obstacle mentioned by teachers, namely, the perception that the curriculum is excessively extensive. For instance, teacher 13 expressed, "[…] the main limiting factor is time. Our class time, we have an exceptionally large curriculum, it is an extensive curriculum." While this finding aligns with results from other studies [20,28,30], it is worth noting that time constraints are not considered a significant challenge according to education stakeholders in Ireland, as indicated in the study by McCauley et al. [39].

Another obstacle identified in the literature regarding the implementation of OL in formal education is the gap in teacher training concerning ocean and marine environment themes [40–42]. For example, studies conducted by Boubonari et al. [43] and Mogias et al. [26] revealed through the answers to questionnaires applied to university graduates in Greece that these aspiring professionals primarily acquire information on these themes from traditional media and the internet, rather than through their university education. This lack of specific education was also highlighted in the study by McPherson et al. [28], where only two out of 17 science professors interviewed in Nova Scotia, Canada, claimed to have received training related to ocean sciences. An analogous situation exists in Brazil, where professional education was also cited as a significant barrier by teachers. While some Brazilian teachers reported studying subjects related to the marine environment during their undergraduate studies, they expressed limited knowledge of these themes and recognized the need to "update their understanding of these contents" (teacher 23). To bridge this training gap, teachers seek to obtain "information from textbooks […]" or "search for sources on the internet" (teacher 44).

Similar to the Canadian teachers interviewed by McPherson et al. [28], the majority of Brazilian teachers in this study acknowledged the importance of knowledge about the ocean and marine environments. However, while Canadian teachers emphasized the importance in relation to ecosystem services, Brazilian teachers identified four aspects:

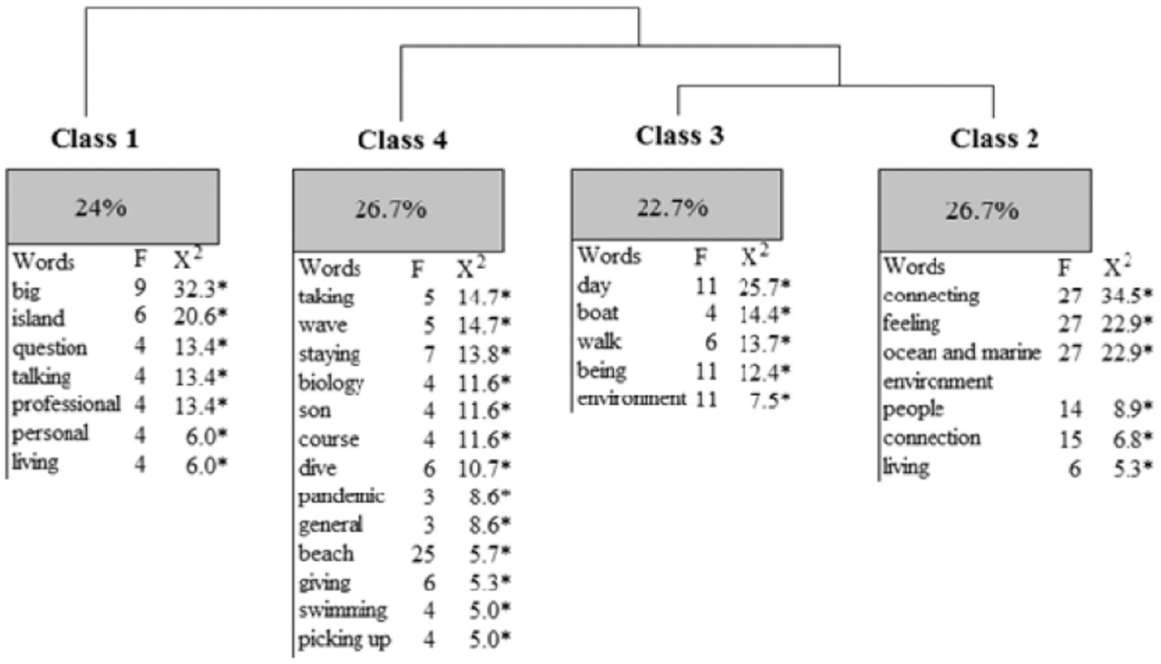

Fig. 3. Dendrogram of descending hierarchical classification of the textual corpus on the respondent's connection with the ocean and marine environment. F: frequency of occurrence of the words listed within each class; χ^2: chi-square test values; *significant values ($p < 0.05$).

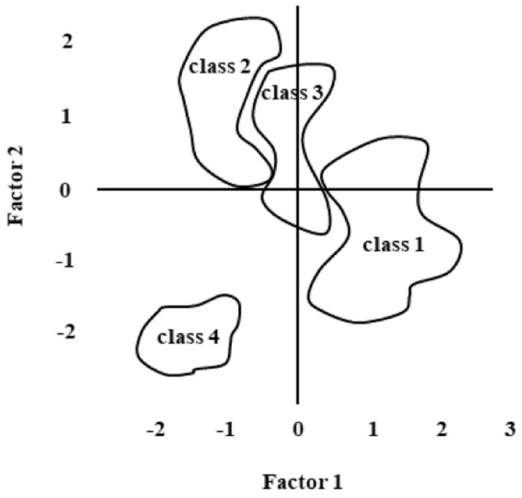

Fig. 4. Factorial correspondence analysis of the textual corpus on the respondent's connection with the ocean and marine environment.

relevance to students' daily lives (reflected in words such as student, related, recognition, and training), raising awareness (reflected in words such as life, person, planet, garbage, knowing, importance, and understanding), ecosystem services (represented by words such as city, climate, population, economy, and working), and the lack of knowledge about the ocean (related to words such as giving, attention, and content).

From the perspective of Brazilian teachers, the inclusion of ocean and marine-related content in university curricula and the implementation of ongoing professional development programs were identified as crucial measures to bring ocean themes into Brazilian classrooms. These demands have also been expressed by teachers in Australia [30] and Ireland [39]. However, studies such as those by Boubonari et al. [40] and Mogias et al. [43] have indicated the significance of teachers' personal connection with the ocean as a relevant factor in incorporating ocean themes in their classes. For instance, Eidietis and Jewkes [29] conducted research with science teachers in the United States and found that positive attitudes toward ocean science influenced the inclusion of such themes in their teaching. In the case of Brazilian teachers, their connection with the ocean and marine environments is evident through admiration (represented by words such as relation, living, and strong), emotional and spiritual relationships (identified in words such as connecting, feeling, child, and spiritual), leisure (related to words like boat, ride, and sensation), and professional engagement (identified in words such as biology, course, and diving).

The challenges in implementing OL in formal education settings have been extensively discussed in countries of the global north [7,20,28,30,39,44]. However, this study is the first to present data for a country in the global south. Although the investigation was concentrated on teachers from coastal municipalities in the State of Rio de Janeiro and data from other Brazilian regions (coastal and non-coastal) are desirable, the interviews were made in an urban center that concentrates and radiates culture and ideas to the country as a whole. Therefore, in certain extent it represents a good baseline of what are the ideas of teachers from other parts of the country, both due to influence and concentration of professionals from other Brazilian regions. Another point to take in consideration is that the challenges and solutions for including the ocean in schools pointed out by teachers from other countries, with very different characteristics from Brazil, are very similar to what was mentioned by the teachers interviewed in this study [7,20,28–30,39,44]. Thus, despite the geographical, economic, and political differences between countries in the global north and south, the three primary barriers to teaching content about the ocean and marine environments are consistent: the absence of content in the school curriculum, inadequate coverage of the marine theme in university education, and insufficient time to address these topics in class [20,28,30,39,44]. However, notable differences were observed in the perception of Brazilian teachers regarding the challenges faced in implementing OL. For example, the lack of didactic resources on the ocean and marine environments was a major challenge mentioned by teachers in Canada [28], the United States [44], and England [20], but was less frequently cited by Brazilian teachers. On the other hand, Brazilian teachers highlighted difficulties such as limited time for class preparation, challenges of interdisciplinary work, and a lack of support and resources for

field trips. Thus, overcoming the barriers to teaching OL in Brazilian schools requires strategies already identified and implemented in the global north, as well as measures tailored to the specificities of Brazil, such as valuing education professionals, supporting interdisciplinary work, and providing resources and support for field trips. The present study aims to serve as an information source for all stakeholders interested in promoting OL in classrooms to achieve the objectives of the Ocean Decade.

5. Conclusion

Teachers play a crucial role in introducing concepts and themes related to OL in schools and increasing awareness among young people about the impact of the ongoing environmental crisis on the ocean. However, Brazilian teachers, like their counterparts in the USA, Europe, and Australia, face shared challenges in implementing OL in classrooms, including mainly the absence of ocean and marine themes in school curricula (cited by 18.7% of the interviewee), a lack of professional training on these subjects (13.1% mentions to this problem), and limited time for class preparation (12.1% complained of that). These obstacles are not unique to Brazil but are prevalent worldwide.

In addition to these familiar challenges, teachers also reported barriers which are specific to Brazilian reality such as the appreciation of education professionals, the need for interdisciplinary education support, and the provision of financial resources for schools. However, Brazilian teachers demonstrated strong personal connections with marine environments, as shown by the dendrogram of descending hierarchical classification of the textual corpus on the respondent's answers. Their connection with the ocean and marine environment are related to: (1) sea fascination (24% of the answers in the textual corpus), (2) spiritual and emotional connection (26.7% of the textual corpus), (3) leisure (22.7%) and (4) professional interest (26.7%). Furthermore, the textual corpus also identified teachers recognition of the importance of content related to the ocean and marine environments for student education because students live in a coastal area (32.2% of the answers in the textual corpus), marine environments provide important ecosystem services (19.9% of the textual corpus), preservation issues (34.2%), and limited knowledge of students on these themes (13.7%).

In this context, the challenges for implementing OL may seem small when compared to the possibilities and benefits that arise when appropriate material conditions are provided through public policies that support formal education.

CRediT authorship contribution statement

Carmen Edith Pazoto: Investigation, Methodology, Writing – original draft, Writing – review & editing. **Michelle Duarte:** Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Edson Pereira Silva:** Conceptualization, Formal analysis, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

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.

Data Availability

Data will be made available on request.

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