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University Extension and Informal Education: Useful Tools for Bottom-Up Ocean and Coastal Literacy of Primary School Children in Brazil

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While increasing awareness about ocean-related topics is a matter of urgent necessity, ocean and coastal-literate schoolchildren are uncommon in Brazil, even in coastal cities. In the present study, we report the activities of an environmental education project spanning a 3-year period in São Vicente, a city surrounded by marine habitats in the southeastern state of São Paulo. This project was part of a university initiative aiming to promote shared knowledge between marine biology student-monitors and the encircling community. With the aid of informal and practical educational activities, we introduced topics of marine zoology, marine ecology, waste management and recycling to 200 fifth-year primary students. Using pre- and post-instructional questionnaires, we evaluated the students' general knowledge of provided ocean and coastal literacy topics. Our results showed a significant difference between initial and final perception across all questions, with a higher questionnaire score after activities. The highest increase in perception concerned lessons on the marine fauna found around the school (94.6% from the initial 7.9%), pointing to the intrinsic value of teaching biological sciences from a zoological perspective. Increased knowledge retention was also observed in lessons on pollution (52.6% from 26.7%), recycling (77.2% from 61.9%), and regional waste treatment (51.8% from 24.2%). Overall, this initiative proved to be a fruitful addition to the school curriculum, especially considering the relevance of rapid urbanization, environmental degradation and water pollution in São Vicente and the role these children might exert as critical-thinking citizens in the future. On the other end, our monitors were also provided with the opportunity for an informal teaching environment complementary to their usual academic-centric degree, with a fresh perspective on accessible scientific communication.

Keywords: university outreach, environmental education, elementary students, marine zoology, recycling

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INTRODUCTION

University extension, also known as university outreach, is considered one of the three pillars of higher education institutions in Brazil, a position shared alongside education and research (Brasil, 1988[1]). It can be defined as any educational, cultural or scientific activity that "extends" academic practices to the surrounding community while bringing traditional knowledge into the university, promoting dialogue and generating shared experiences (de Paula, 2013). In this context, projects aimed at complementing gaps in civic education, especially children's, can be a valuable asset to society while offering the opportunity for the development of teaching and communication skills of university students.

The role of environmental education in generating critical-thinking citizens is a topic that gained traction following Rio de Janeiro's 1992 Earth Summit (Rio +20), manifested in the Agenda 21, a major program which established the necessary steps to achieve sustainable development in the 21st century. One of such steps, on Promoting Education, Public Awareness and Training, culminated years later in the Política Nacional de Educação Ambiental (National Policy on Environmental Education); this policy aims to guide both formal and informal teaching of environmental education at all stages, through interdisciplinary practices and support of local and regional projects in Brazil (Brasil, 1999[2]).

In a sciences program, informal learning encompasses activities ranging from visiting museums and attending lectures, to participating in science fairs and competitions (Dib, 1988). However, the idea of learning through play and exploration is an often-overlooked educational feature (Semper, 1990), especially in the classroom environment where a dialectic approach adopting both formal and informal activities still constitutes a recent trend (Marsick et al., 2017). Accordingly, the latest census administered by the Brazilian Ministry of Education shows that only 11.5% of public primary schools in the country are equipped with biology laboratories, with the majority of teachers still relying on traditional textbooks despite the presence of computer labs in almost half of the schools (INEP, 2017[3]).

Teaching individuals about our ocean and coasts is a necessity to ensure sustainable use of their natural and social resources, i.e., a bottom-up approach (McKinley and Fletcher, 2010). This is turn should be accompanied by a top-down strategy of policies and regulations concerning said resources (Mora et al., 2009). Yet, even though the ecological, economic and social value of the ocean has been long postulated (Costanza, 1999), anthropic activities still offer a threat to the maintenance of the marine environment (Lotze et al., 2006; Worm et al., 2006; Andrady, 2011). Such a trend arises from an ocean-illiterate general population (Spruill, 1997; Steel et al., 2005), with formal strategies to communicating ocean science to young people being severely deficient in a number of countries (Cummins and Snively, 2000; Ballantyne, 2004; Guest et al., 2015).

To be implemented until 2020, the Base Nacional Comum Curricular (National Common Curricular Base) is a general policy setting to guide school curriculums of both public and private preschool, primary and secondary institutions in Brazil. According to its guidelines, ocean science is to be taught at grade eight of primary education, as an introduction to ocean circulation (MEC, 2018[4]), with no mentions of marine or coastal environments made over the remainder of the document. While employing knowledge to reduce human impacts on the ocean is at the core of ocean literacy (McKinley and Fletcher, 2010), current education efforts appear to be doing little to advance this paradigm (Guest et al., 2015).

The present study aims to report the activities of an extension program entitled *Pet-mar: using recycled material to teach about marine animals* (Mar is Portuguese for "sea"). This project spanned three years and took place at a public primary school in São Vicente, Baixada Santista metropolitan area, a city with relevant socio-ecological connections to the sea in São Paulo, Brazil (**Figure 1**). With a playful and spontaneous way of teaching, we shared marine zoology, ecology, conservation and recycling concepts with fifth-year public school students. Our aim was to address the importance of the marine environment surrounding the school, the impacts of inefficient waste management policies and how each student could do their part in preserving the ocean for future generations, thus helping produce ocean and coastal-literate citizens.

MATERIALS AND METHODS

The initial contact with the school was established by communicating our proposal to the school coordinator and principal. Once permission was granted, a resident teacher and the school coordinator accompanied all activities, while our team was composed of undergraduates monitored by senior year marine biology students. We taught three classes in 2014 and two classes in 2015 and 2016 each, supervising 200 students aged 10–11 within this time span. We held weekly meetings with the school coordinator and principal, as well as the project coordinator at the university.

Our project underwent three phases. The first phase, executed within the first school semester (March–July), consisted of expositive lessons on zoology and ecosystem ecology, with content supplementary to the school's curriculum and the Plano Nacional de Educação (National Education Plan). The second phase focused on pollution and the societal implications of an inefficient waste management system, also following the curriculum. The final phase had the children in full command of their actions in the form of crafting sessions, which culminated in the confection of marine animals from reused material, i.e., "pets". This term refers to companion animals while also being a wordplay on polyethylene terephthalate

[1]https://www.senado.leg.br/atividade/const/con1988/con1988_18.02.2016/art_207_.asp

[2]http://www.planalto.gov.br/ccivil_03/LEIS/L9795.htm

[3]http://download.inep.gov.br/educacao_basica/censo_escolar/notas_estatisticas/2018/notas_estatisticas_Censo_Escolar_2017.pdf

[4]http://basenacionalcomum.mec.gov.br/abase/#fundamental/ciencias-no-ensino-fundamental-anos-finais-unidades-tematicas-objetos-de-conhecimento-e-habilidades

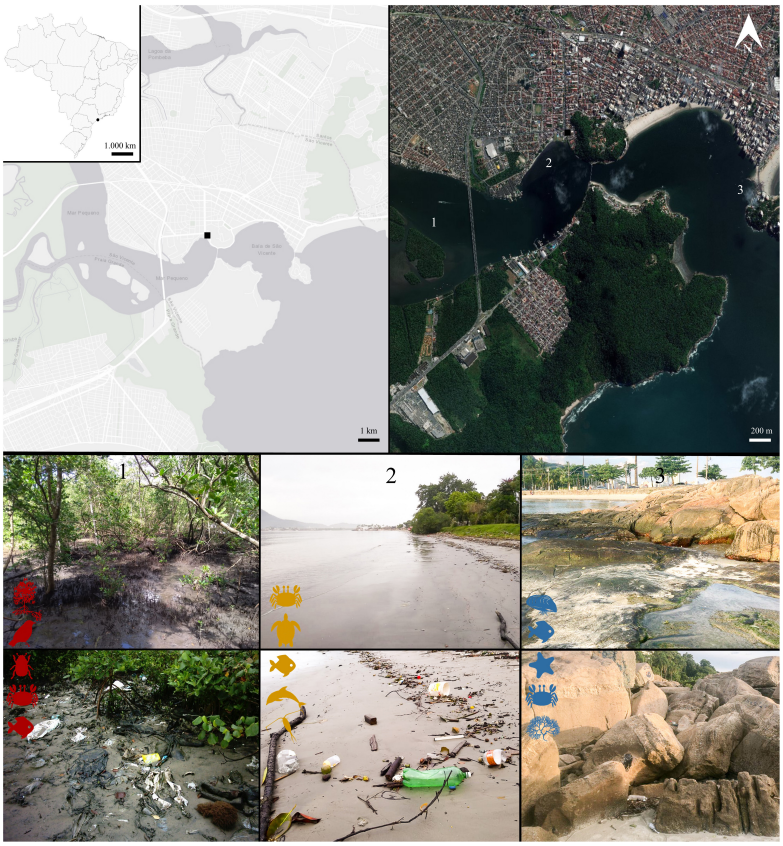

FIGURE 1 | Map of São Vicente (shown as black circle), São Paulo, Brazil, highlighting the school's location (black square) and surrounding coastal and marine habitats which were discussed during the project: mangroves (1), sandy beaches (2), and rocky shores (3). Contrasting states of pollution are show for each habitat (top – clean; bottom – polluted). Main fauna and flora groups explored in our activities are represented as vectors for each habitat (top to bottom). Mangroves (red): mangrove trees, birds, insects, crustaceans and fishes; sandy beaches (yellow): crustaceans, marine reptiles, fishes, marine mammals and zooplankton; rocky shores (blue): mollusks, fishes, echinoderms, crustaceans and algae. All vectors are released under the Creative Commons CC0 License.

(PET), the main component of soft drink plastic bottles. Both second and third phases took place within the second semester (August–December).

Following Resolução #510/2016 (Brasil, 2016[5]), article 1, paragraphs VII and VIII, this study was exempt from ethics evaluation by the Comitês de Ética em Pesquisa/Comissão Nacional de Ética em Pesquisa (Committee for Ethics is Research/National Committee for Ethics in Research). This work was carried out in accordance with and approved by the Comissão Permanente de Extensão Universitária – UNESP (Permanent University Extension Committee). All respective guardians gave written informed consent for children participation and image publication in accordance with the Declaration of Helsinki.

Activities

What Is There?

Our first meeting with the children concerned the meaning of biodiversity and ecosystem. Following this exposition, we presented the students with a sensorial museum: three opaque boxes with a frontal opening big enough for their hands to fit in, but with otherwise indiscernible content save by touch (**Figure 2A**). Each box had a plastic tray filled with (1) mud and leaf detritus, (2) beach sand, or (3) salt water and rocks, mimicking a mangrove, a beach and a rocky shore, respectively. We then asked the students to decide as groups which marine ecosystem was being represented.

Our Surrounding Environment

The second activity took advantage of the school's projector and whiteboard to show how these environments were inserted within the city, and which organisms inhabited each one (**Figure 2B**). We employed satellite images of the area surrounding the school as well as pictures of the fauna more commonly found there to show just how close the children were to those habitats (e.g., mangroves, rocky shores) (**Figure 1**).

Sea Creatures in Land!

The third activity consisted of us showing the children coastal and estuarine specimens from the university's research projects and zoological collection, while inviting participants of another

[5]http://bvsms.saude.gov.br/bvs/saudelegis/cns/2016/res0510_07_04_2016.html

FIGURE 2 | Activities promoted by the project: **(A)** What is in there?; **(B)** Our surrounding environment; **(C)** Sea creatures in land!; **(D,E)** Understanding marine plankton (with main observed phyto- and zooplankton specimens represented inside the white rectangle); **(F)** Think fast and recycle!; **(G,H)** Our marine "pet" workshop.

extension project within our university, the Museu Itinerante de Biologia Marinha (Itinerant Museum of Marine Biology, MIBIM), into the classroom (**Figure 2C**). This was, for the majority of students, their first contact with marine and coastal organisms such as sea urchins, sea turtles and sharks. During this lesson, we asked the students to associate each organism with its most likely environment, thus establishing a link with the previous activity.

Understanding Marine Plankton

Our final lesson for the semester took place outside the classroom at a nearby beach. The children were presented to the concept of (phyto- and zoo-) plankton and its relevance to the marine food web while one of our monitors showed how to collect it (**Figure 2D**). The material was then brought back to campus and displayed on stereomicroscopes, while we showed how to identify the most common organisms (**Figure 2E**). This was the children's first contact with analytic equipment and their first time entering the university.

What Is Pollution and How Does It Affect Us?

Following the initial themes of biodiversity and ecosystems, we adopted a pollution and recycling-oriented approach to second semester classes. The first activity was a lesson on the different types of pollution (e.g., visual, sound) and how each of them affected the environment (e.g., atmospheric smog, plastic entanglement of marine organisms and improper waste disposal in dumps). We then divided students into groups and asked them to mimic specific types of pollution and their effects on the environment. Once again, we stressed how these concepts applied to our surrounding ecosystems (**Figure 1**).

Think Fast and Recycle!

This lesson consisted of a competition in which students had to quickly associate recyclable materials with their standard bin colors (i.e., red for plastic, green for glass, yellow for metal and blue for paper in Brazil) (**Figure 2F**). This activity took place in the sports court located in our campus.

Where Does Our Trash Go?

For our last activity on waste management, we screened the short film Isle of Flowers (Furtado, 1989), which narrates the path of organic material, from harvesting to the dump, drawing a heavy critique of the conditions faced by impoverished communities in Brazil. We then proceeded to discuss the Política Nacional de Resíduos Sólidos (National Policy on Solid Waste) and how little information the children had regarding the destination of their own waste, even in a city with a selective collection program like São Vicente.

This Is Why We Are Right. . .

We split the students into two groups to debate *how to draw interest into environmental education*. One group defended an emphasis on man-made impacts on the environment and the importance of industrial production to societal development while the other defended an emphasis on conservation and the relevance of pristine environments. We hoped to make them realize this was precisely our project's aim, and both approaches had their merit, especially when juxtaposed.

Our Marine "Pet" Workshop

For the final set of activities, we introduced the third phase of the project. From the start of the project, children were incentivized to save recyclable material such as cartons, bottles, cans, and cardboard boxes. Students then brought these materials to school and we provided them with paper, glue, paint, paintbrush, scissors, etc. We asked the children to create any marine animal from the available materials, and creations took the form of barnacles, corals, octopuses and whales, to mention a few (**Figure 2G**).

Our final meeting had the students present their artwork and give a short summary of the chosen organism. "Pets" were initially put on display for a week in a reserved section of the school before the children took them home (**Figure 2H**).

Survey Design and Distribution

In the final year of our project, the children answered pre (Q1) and post-instructional (Q2) electronic surveys. Both questionnaires were identical and consisted of 10 multiple-choice questions (**Table 1**), encompassing ocean literacy principles five, *The ocean supports a great diversity of life and ecosystems* and six, *The ocean and humans are inextricably*

interconnected (College of Exploration, 2015[6]), as well as topics concerning waste management in São Vicente. A third, facultative open-answer survey (Q3) applied in conjunction with Q2 inquired students about their favorite (and least favorite) activity throughout the project and suggestions for future activities (**Table 2**).

Data Analysis

We graded the questionnaire out of the previously mentioned 10 questions (Q1 and Q2) with right answers having the same weight. We checked the data for normality and homoscedasticity using Shapiro-Wilk and Levene's tests, respectively. We applied the non-parametric and two-way crossed permutational multivariate analysis of variance (PERMANOVA) considering the period of application of our questionnaire (initial and final) and gender as fixed factors. PERMANOVA is robust for non-normal distributions and univariate analysis applied to Euclidean distance matrices (Anderson et al., 2008; Uribe et al., 2015). The critical level (α) was set at 95% of confidence interval ($\alpha = 0.05$). Values throughout the text are reported as mean $\pm$ standard error.

RESULTS

In total, 63 students took part in Q1 and 58 in Q2 and Q3, with 50.7 and 39.5% identifying as female, 41.2 and 48.2% as male, and 7.9 and 12% as other or choosing not to respond, respectively. Students showed an overall significant change in perception on provided ocean and coastal literacy topics after our activities (PERMANOVA: $F = 3.9717$, $Df = 1$, $p = 0.0041$) independent of their gender (PERMANOVA: $F = 0.61901$, $Df = 2$, $p = 0.5297$) (**Table 3**). Average Q2 score (4.81 ± 0.24) was higher than average Q1 score (4.14 ± 0.24), and answers also varied as the proportion of correct answers among topics (**Table 4**). Highest increase in perception was observed for lessons on regional biodiversity (94.6% correct answers from the initial 7.9%), pollution (52.6% from 26.7%), recycling (77.2% from 61.9%) and regional waste treatment (51.8% from 24.2%). The definition of ecosystem, however, had a lower retention, and lowest across all questions, by the end of the activities (3.6% from 12.7%). As for Q3, the majority of students (98.1%, 53 out of 54) agreed that the project was important to them, with one student answering "partially" (1.9%, 1/54), and that there was no need for structural change (91.3%, 42/46), but no suggestions on what could be changed for those who said "yes" (8.7%, 4/46). Their favorite activity was "Understanding marine plankton" (71.1%, 27/38), followed by "Think fast and recycle!" (13.1%, 5/38), "Our marine 'pet' workshop" (7.9%, 3/38), and theoretical classes in general (7.9%, 3/38). Only four children mentioned their least favorite activity: "Where does our trash go?" (50%, 2/4), followed by "Think fast and recycle!" (25%, 1/4), and theoretical classes (25%, 1/4).

[6]http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/principles-and-concepts

TABLE 1 | List of multiple-choice questions asked on Q1 and Q2.

Question
1. What is the best definition of ecosystem?
a. Series of natural landscapes
b. Environmental aspects (air, water, and soil) not yet affected by human action
c. Interaction between organisms and the environment
d. Place where waste reuse takes place
2. What is biodiversity?
a. Ecosystem diversity
b. Variety of life in the planet
c. Number of animal species
d. Ratio between living and dead beings
3. What are some of the ecosystems found in the Baixada Santista?
a. Mangrove, estuary, beach, rocky shore, restinga, and Atlantic Forest
b. Beach, estuary, desert, mangrove, and Atlantic Forest
c. Atlantic Forest, caatinga, beach, estuary, and mangrove
d. Rocky shore, beach, mangrove, desert, caatinga, and Atlantic Forest
4. What animals are commonly found in mangroves?
a. Sea stars, mussels, crabs and dogs
b. Fishes, pigeons, crabs and whales
c. Snakes, rats, cockroaches and cats
d. Crabs, fish, birds, and insects
5. How does the inadequate disposal of household waste affect the environment?
a. It generates pollution
b. It induces species loss
c. It creates an environmental imbalance
d. All of the above
6. What is organic waste?
a. Plant/animal material, or similar to, which is rapidly degraded
b. Plant material which is rapidly degraded
c. Material from domesticated plants/animals, which is rapidly degraded
d. Material destined to recycling
7. What is recyclable waste?
a. All man-made waste
b. Waste from plants/animals
c. Waste that does not decompose
d. Waste that can potentially be used in new ways
8. What is the purpose of selective waste collection?
a. It promotes reuse of all domestic waste
b. It promotes reuse of all industrial waste
c. It promotes reuse of recyclable waste
d. None of the above
9. What is the final destination of the common waste collected by trucks in São Vicente?
a. Sewage-treatment plant
b. Sanitary landfill
c. Ocean
d. The waste in burned
10. What is anthropogenic action?
a. Activity caused by city people
b. Activity caused by country-side people
c. Activity caused by people everywhere
d. Activity caused by people in first-world countries

Correct answers are in bold.

DISCUSSION

Our results show that the project had an overall positive impact on the children's knowledge of marine and coastal environments,

TABLE 2 | List of questions asked on Q3, along with the number of children who chose to answer each question in bold.

Question
1. Did you think Pet-mar was relevant to your studies? **54**
2. Is there anything we can do to improve the project? **46**
3. What was your favorite activity? **38**
4. What was your least favorite activity? **4**

TABLE 3 | PERMANOVA test on differences in students' questionnaire scores across period (initial and final) and gender (male, female, and other/not mentioned) as fixed and orthogonal.

Source	Sum of sqrs	*Df*	Mean square	*F*	*p*
Period	0.33794	1	0.33794	3.9717	0.0041
Gender	0.10534	2	0.05267	0.61901	0.5297
Interaction	−2.4308	2	−1.2154	−14.284	0.6514
Residual	9.785	115	0.085087		
Total	7.7975	120			

TABLE 4 | Results [i.e., proportion (%) of correct answers] from Q1 and Q2.

	Correct answers (%)	
Question	Q1	Q2
1. Ecosystem definition	12.7	3.6
2. Biodiversity definition	35.5	35.2
3. Regional habitats	45.2	39.3
4. Regional biodiversity	7.9	94.6
5. Pollution	26.7	52.6
6. Organic waste treatment	37.7	35.1
7. Recycling	61.9	77.2
8. Regional recycling	58.1	58.9
9. Regional waste treatment	24.2	51.8
10. General anthropogenic impacts	53.9	60

as well as waste destination in their own city, by either improving or reinforcing their pre-existing notions. Children's feedback also highlights that playful teaching practices supported by didactic materials are powerful tools in ocean and coastal literacy activities. Lower final perception in questions one, two, and three could be due to our approach during the initial stages of the project, which focused primarily on definitions instead of general processes. Additionally, these suboptimal results could have been affected by time-interval selection biases, considering the eight-month period between the first activities and the final questionnaire. A slight loss of perception on question six could similarly be explained by its reliance on a vocabulary-heavy definition, as children (and teachers) become turned off science as it becomes a content-led subject (Alexander and Flutter, 2009). While we must stress the possible perception biases on early and late activities, question four: "regional biodiversity," stands out. An almost 12-fold increase in perception and retention of a topic discussed during the first phase points to the intrinsic enthusiasm elicited by zoology among children in this age group (Ballantyne, 2004; Baram-Tsabari and Yarden, 2007), and how it can promote enduring conceptual understanding. The "sea creatures in land!" and "understanding marine plankton" lessons had the children interact with real organisms and were the two activities immediately related to question four. Indeed, Pugh (2002) argues that, in a zoology class, the crafting of ordinary and uninspiring content into compelling ideas is more efficient at creating fullness of perception than the traditional instructional teaching methods we hoped to avoid throughout this project.

During this three-year period, we dealt with themes pertaining to UNESCO's (United Nations Educational, Scientific and Cultural Organization) Sustainable Development Goal (SDG) 14, "Life below Water." A framework for ocean literacy teaching, SDG 14 aims to promote a behavioral shift toward sustainable exploitation of marine resources and preservation of the Earth's ocean and seas (Santoro et al., 2017). In regard to its (1) cognitive learning objectives, students developed an understanding of basic marine ecology and the threats to ocean systems in the form of pollution, (2) socio-emotional learning objectives were mainly fulfilled by giving the children the opportunity to see how their own impacts on the ocean could be minimized via basic activities such as recycling, and (3) as for behavioral learning, students understood the dependence and intrinsic relationship of their region to the ocean and its attributes. The basis of our ocean and coastal literacy activities, in summary, consisted of teaching about the surrounding habitats and socio-ecological problems of the city. Educational approaches using locally sensitive matters, accordingly, are crucial in promoting more efficient environmental education projects (Jenkins, 2003). As many cities worldwide face similar socio-environmental issues, activities analogous to our project could be important in providing local environment knowledge and bringing the real perception of environment issues to future social actors (Amaral et al., 2014; Santos et al., 2018; Ghilardi-Lopes et al., 2019).

The long history of ocean exploitation in São Vicente dates back to its own foundation, when the need of the Portuguese colonizers for maritime communication dictated the location of the first organized town in the country (Moraes, 2007). From the latter half of the 20th century, coastal agglomerations in southeast Brazil also began to serve as beach resorts, bringing rapid urbanization to the region while invariably causing further degradation of local biomes such as the Atlantic Forest and associated mangroves and restingas (Afonso, 2006). In addition to ecosystem loss, water pollution is an especially critical issue in the São Vicente Estuary, with contaminants ranging from plastic-derived micropellets found in beach sediments (Turra et al., 2014) and local bivalves (Santana et al., 2016), to persistent organic pollutants from domestic sewage and port activities (Bícego et al., 2006). In this case, awareness of one's own environment is a fundamental aspect in leading to societal commitment and actions that promote positive environmental change (Ardoin and Merrick, 2013[7]).

[7]https://nmardoin.people.stanford.edu/sites/g/files/sbiybj4916/f/Grantmakers%2010.6.pdf

Our project was conceived under the urgent need for scientific literacy opportunities in our surrounding community. Accordingly, traditional public ocean literacy efforts in Brazil have been mainly restricted to exhibitions, such as the ones hosted by aquariums (Holanda et al., 2015), and the Programa de Mentalidade Marítima (Maritime Mentality Program) (CIRM, 2018[8]). Over the last 20 years, however, environmental education initiatives dedicated to dialogue promotion within the classroom have become more widespread. The Instituto Curicaca (Curicaca Institute) is one of such organizations seeking to build upon traditional community knowledge of the Atlantic Forest biome in Rio Grande do Sul (Bohrer et al., 2009). Educators in the Graduate Program in Marine Sciences Applied to Teaching at the Federal Institute of Santa Catarina – Itajaí, also seek to inform public school teachers and promote ocean literacy in southern Brazil (Berchez et al., 2016). Similarly, MIBIM employs undergraduate student-monitors to bring zoological collection specimens into the school environment in the Baixada Santista (Freitas et al., 2018). Given that primary students are near-future active citizens with potential involvement in socio-environmental problems, ocean and coastal literacy activities are important tools in providing a wider and more realistic view of those issues (Santos et al., 2018).

Our study shows how informal extension projects such as Petmar are a viable option for students interested in following a teaching career, since they offer a fresh perspective on accessible scientific communication (Barzano, 2008). Ocean literacy, in this context, is an ideal point of entry for the non-academic public into the university, while also providing contact with a non-traditional model of environmental education activities. This is especially relevant in a country where only 16.6% of the population between 25 and 34 holds a tertiary education diploma (OECD, 2018[9]), and local ecosystem knowledge is a low priority in environmental education projects (Loureiro et al., 2007). In contrast, recycling, pollution and general biological diversity figure among the top five environment education themes discussed in Brazil (Loureiro et al., 2007). Our project encompassed all of these topics, but future editions could include more interdisciplinary activities focusing on economic and social aspects of environmental education, as well as ways to increase teacher participation in such activities (see McGregor, 2012). Additionally, for some environmental themes our evaluation highlights the need for adapted definitions, closer to children's vocabulary. Finally, our future endeavors ought to focus on even earlier stages of primary education, with integration across all grades.

[8]https://www.marinha.mil.br/secirm/promar

[9]https://data.oecd.org/eduatt/population-with-tertiary-education.htm

AUTHOR CONTRIBUTIONS

GS-S and JP contributed equally to the design and execution of activities during the project, and had an equal participation on the writing of this manuscript. PP supervised activities as school coordinator. TC envisioned the project and supervised its monitors.

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