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ARTICLE

Implementation of a Pedagogical Model of Ocean Citizenship: Students' Perspective

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Abstract
This article evaluates the implementation of the pedagogical model by Schio and Reis (2024), aimed at promoting ocean citizenship within basic education. The evaluation is based on a pilot project from the 2021/2022 school year, which involved 543 students, aged 10 to 11, from 10 Blue Schools located along the Portuguese coast. This paper reports on phases 3 and 4 of the Design-Based Research cycle, corresponding to the implementation and evaluation phases of the pedagogical model. Preliminary results allowed us to verify the emergence of new knowledge, skills, values, critical thinking and attitudes, reflecting the development of ocean citizenship competencies among students. These outcomes affirm the model's applicability and its potential to seamlessly integrate ocean citizenship into the basic education curriculum. However, it was observed that the activism dimension requires additional emphasis. Further testing in diverse educational settings is crucial to refine the model, adjust to local nuances and maximise its impact on nurturing future generations committed to ocean sustainability.

Keywords: Ocean citizenship; ocean literacy; pedagogical model; primary education; students

Contextualisation

Ocean literacy is a powerful tool for enhancing awareness and understanding of the ocean's critical role and value in our lives (IOC-UNESCO, 2021). It transcends mere skill development and knowledge generation, embodying a systemic and multidimensional strategy to foster behavioural shifts. This approach aims to cultivate ocean citizenship, engaging society at large in devising and applying solutions to contemporary oceanic challenges (Brennan, Ashley & Molloy 2019, IOC-UNESCO, 2021; McKinley, Burdon & Shellock 2023; NOAA, 2021). A broader concept of ocean citizenship involves understanding the relationship between our daily lives and the health of the marine environment, exercising the right to participate in transforming society's relationship with the ocean and accepting responsibility for informed personal and collective actions that contribute to a sustainable marine environment (Buchan, Evans, Pieraccini & Barr 2023; Fletcher & Spotts, 2007; Mckinley & Fletcher, 2012; Mckinley, 2010). It emphasises awareness, behaviour change and advocacy for improved marine governance and health, which are key competencies in ocean citizenship.

Building on this foundation, this article aims to evaluate the students' experience implementing a pedagogical model proposed by Schio and Reis (2024) (Figure 1), designed to foster ocean citizenship through a pilot project carried out in the 2021/2022 school year. The development of the pedagogical model was extensively described in Schio and Reis (2024) applying phases 1 and 2 of the Design-Based Research (DBR) cycle. Grounded in systems thinking principles and literature

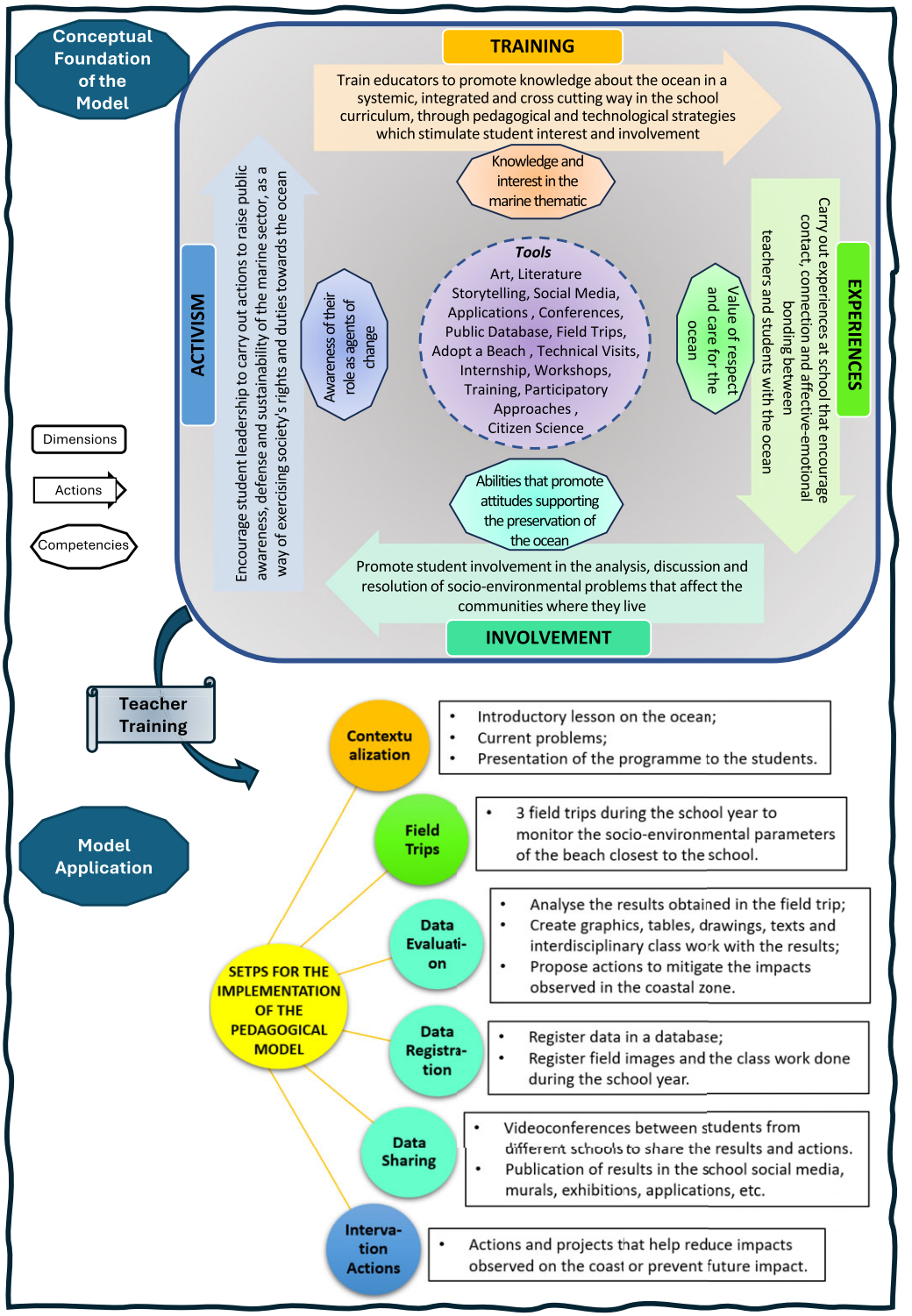

Figure 1. Pedagogical model for promoting ocean citizenship in basic education as proposed by Schio & Reis (2024, p.16).

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on ocean literacy and citizenship, it merges conceptual and practical aspects through citizen science and youth activism to engage students in research, monitoring and conservation activities along their coastlines.

The conceptual component of the model encompasses four dimensions — training, experiences, involvement and activism — each associated with specific actions and competencies for development, complemented by a toolkit to stimulate these actions. Concurrently, the practical component of the model comprises six educational activities tethered to a coastal monitoring project, executed by students under teacher guidance (Figure 1). This paper reports on phases 3 and 4 of the DBR cycle, corresponding to the implementation and evaluation phases of the pedagogical model, providing outcomes that assess the applicability and educational contributions of the model to foster ocean citizenship in basic education.

Studies suggest that enhanced ocean literacy leads to greater valuation of marine environments (Guest, Lotze & Wallace 2015), respect for the sustainability of marine ecosystems (Santoro, Santin, Scowcroft, Fauville & Tuddenham 2017) and a heightened willingness to endorse policies promoting ocean health (Steel et al., 2005). To address the critical challenge of fostering societal involvement in ocean sustainability by 2030, it is essential to develop strategies that strengthen social connections with the ocean, especially among those with limited access to the sea (Kelly et al. 2022). Consequently, adopting a systemic perspective that acknowledges the complexity of the human–ocean relationship is crucial for creating innovative approaches to support this end.

According to McKinley et al. (2023), this complexity includes ten dimensions that should be integrated in ocean literacy initiatives: knowledge, communication, behaviour, awareness, attitudes, activism, emotional connection, access and experience, adaptive capacity and trust and transparency. The success of these initiatives will largely depend on effectively integrating these dimensions and employing new strategies to actively engage citizens in marine conservation. Building on this framework, ocean literacy endeavours should extend beyond ocean science to encompass experiential learning, access to innovative technologies and insights into citizenship, personal and social responsibility, and the nuances of translating knowledge into actionable outcomes (Fielding et al., 2019; IOC-UNESCO, 2022; Kelly et al., 2022; Santoro et al., 2017).

Proposing concrete, achievable and empowering projects that address local issues can build belief in the feasibility of change (Reis, 2020), thus motivating citizen engagement and their "power to act" towards desired global and marine transformations. The Schio and Reis (2024) pedagogical model (Figure 1) advances these aims, providing a pragmatic and structured approach for fostering ocean citizenship in basic education. By exploring the impact of these pilot experiences on students' learning and the development of ocean citizenship, the study aims to contribute with valuable insights and pedagogical strategies to the broader field of environmental education practice.

Methodology

The pedagogical model was developed through phases 1 and 2 of the DBR method, as detailed in Schio and Reis (2024). DBR is a systemic, interventionist and collaborative approach that incorporates various methodological strategies across iterative cycles of design, reflection and redesign (Ponte et al., 2016; Romero-Ariza, 2014). The DBR cycle consists of four phases: 1) diagnosis, 2) planning, 3) action (implementation) and 4) evaluation (Coghlan & Brannick, 2001) (Figure 2). This article describes the application of phases 3 (action) and 4 (evaluation), presenting the results of the students' experiences in carrying out the activities proposed in the model. A subsequent publication will discuss the teacher evaluation aspect.

Implementation of the pedagogical model (DBR phase 3 — action)

As a pilot project, the pedagogical model was first tested in Blue Schools. Run by the Portuguese Ministry of the Economy and Maritime Affairs, this programme certifies schools dedicated to

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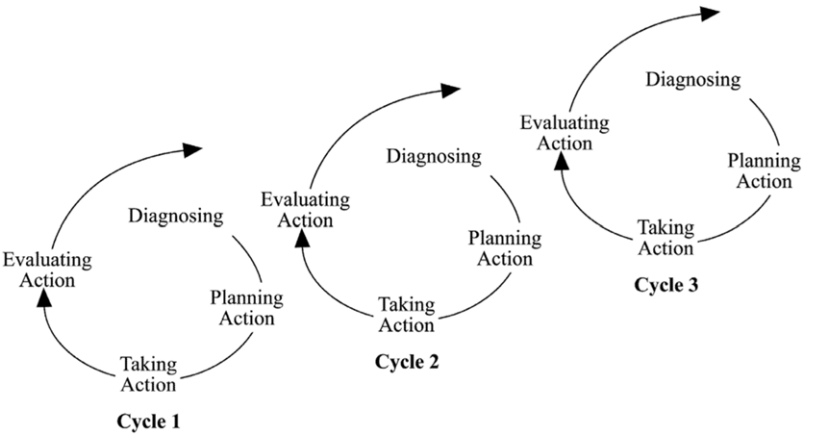

Figure 2. An example of a cyclical design process according to Coghlan and Brannick (2001) (p. 24).

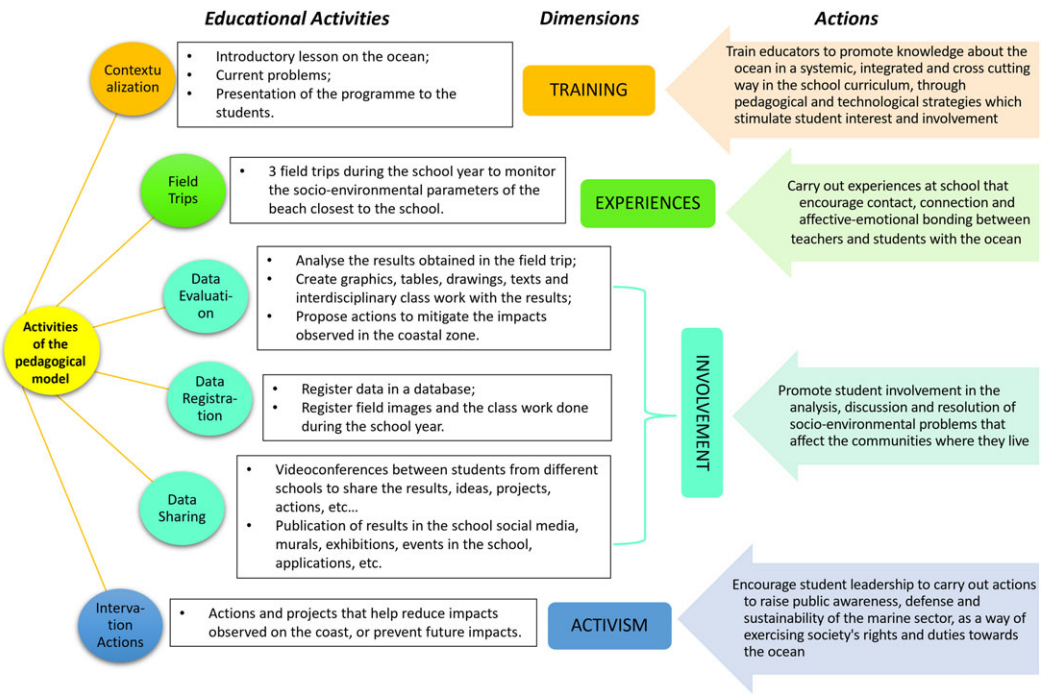

Figure 3. Implementation stages of the pedagogical model's educational activities, linked to its conceptual dimensions and actions, adapted from Schio and Reis (2024) (p.15).

integrating ocean literacy into their curricula, raising awareness of ocean conservation within the educational community (Costa et al., 2021). The model's implementation in schools entailed six educational activities, as defined by Schio and Reis (2024), executed by students under teacher supervision within a coastal monitoring project. These activities included: 1) contextualising ocean-related issues; 2) conducting three beach monitoring outings; 3) evaluating field data; 4) documenting results; 5) disseminating findings; and 6) initiating school/community intervention actions. Figure 3 illustrates the correlation between the six activities and their connection to the

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Figure 4. Distribution of schools participating in the programme along the Portuguese coast.

model's conceptual dimensions and actions. This figure helps clarify these relationships, thereby facilitating the subsequent evaluation of the model's educational impact.

Designed to engage both students and teachers, these activities aimed to: a) foster connections and strengthen socio-emotional bonds with the ocean; b) enhance understanding of their local marine and coastal environments through participatory learning and citizen science research, encouraging active investigation and problem-solving; and c) promote critical reflection on the socio-environmental challenges of their coastal zones, leading to think about potential solutions.

This initiative was embraced by 543 students from 26 fifth and sixth-grade classes, aged 10 and 11, across 10 Blue Schools situated in various Portuguese coastal regions (see Figure 4). The diverse fieldwork settings included twelve coastal beaches, one river beach and two estuary beaches. Schools were advised to prepare a research toolkit comprising compasses, magnifying glasses, mini microscopes, shovels, sieves, measuring tapes, thermometers, buckets, stakes, strings, water analysis kits and more. The research tools are essential not only to facilitate the observation of environmental parameters and objects on the beach, but also to stimulate curiosity, motivation, engagement and the cognitive process during the investigative practice (Figure 5).

For data collection during the coastal monitoring field trips, we utilised the field sheet from the Brazilian Monitoramento Mirim Costeiro programme (www.monitoramentomirimcosteiro.com.br) as a template (Figure 6). This choice was informed by the alignment of Schio and Reis (2024)'s four prescribed field trip analyses with the socio-environmental parameters employed by the Brazilian programme. These analyses comprised: 1) observing the day's weather conditions; 2) assessing seawater quality; 3) conducting a beach sand survey using a 5-square transect, each measuring 2×2 m for a total of 20 m^2 (Figure 5); and 4) examining socio-economic activities, services and structures along the beach.

Guided by their teachers, students were tasked with: a) entering the gathered field data into an Excel file distributed to the schools; b) organising the data into graphs, tables, diagrams, etc.; and c) engaging in analysis, discussion and reflection on the collected data to identify potential enhancements to the observed coastal environment. Teachers were asked to facilitate this process by integrating the results into interdisciplinary curricular activities, bridging them with other

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Figure 5. Coastal monitoring practice illustrations. The left side of the image shows a diagram of the survey transect consisting of five 2 × 2 m squares, totalling 20 square metres. On the right side, illustrations depict the students' performing analyses with their research tools.

subjects. The outcomes were then shared through murals, social networks, and other communication platforms, reaching audiences both within and outside the educational institution. Furthermore, students were encouraged to reflect on the results to think about actionable solutions aimed at addressing the identified coastal issues.

Evaluation of student's experience (DBR Phase 4)

The evaluation of student experiences within the pedagogical model was conducted using face-to-face focus group interviews with each of the 26 participating classes, using the following questions:

1. How was the experience of becoming researchers and beach monitors?
2. Of all the activities you did on the beach, which did you enjoy the most?
3. Was there anything you did not like?
4. What new things did you learn that you didn't know before?
5. What were the main results you found in beach monitoring research?
6. Did you observe any environmental problems or impacts on the coast? What can be done about that?
7. Are you motivated to continue this project throughout the school year?
8. Are you curious to know what students from other schools monitoring other beaches found in their research?
9. Do you have any suggestions for changes or improvements for future activities?

Additionally, a visual analysis of student activities, showcased through videos presented at a year-end videoconference, supplemented this evaluation. The content analysis method was employed to analyse the focus group interview transcripts, involving a systematic interpretation of data to identify patterns, themes and underlying meanings. This approach aimed to draw insightful conclusions about the subject matter (Krippendorff, 2018). Through categorisation and analysis of students' descriptions, reflections and reactions to the activities, it was possible to identified key themes indicative of students' assimilation of ocean citizenship concepts and highlighted potential areas for enhancing the pedagogical model.

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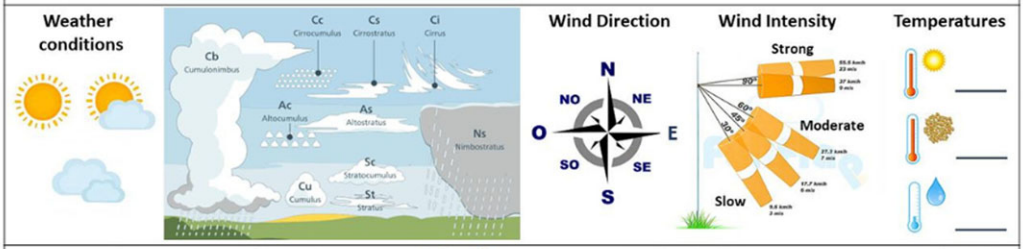
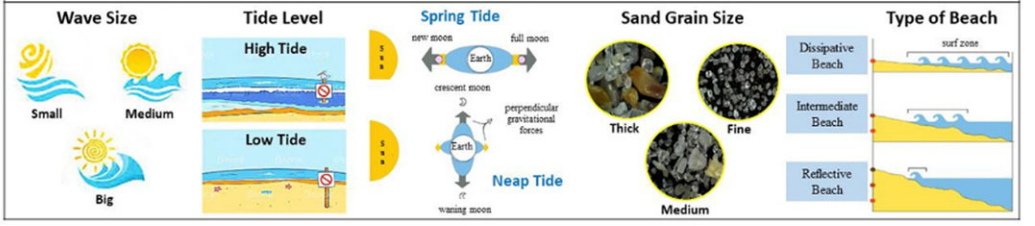
Research Location:	Date:	Start time:
School Name:		End Time:
School Teacher's Name:		





NAME OF THE GROUP:					
UNNATURAL MATERIAL	Number of the sampling square =	TOTAL	NATURAL MATERIAL	Number of the sampling square =	TOTAL
Microplastics			Sea shells		
Pieces of plastic			Vegetation		
Cigarette butts			Seeds		
Nylon			Feathers		
Rope			Insects		
Bottle cap			Stones		
Straws			Algae/seaweed		
Cloth			Pieces of animals		
Styrofoam			Food scraps		
Metal					
Paper					
Ice cream stick					
Cotton swab			OTHER MATERIAL		
Toothpick					
Pieces of glass					
Coal					
Construction debris					
Sponge					

BEACH INSPECTION		ANALYSIS OF THE WATER QUALITY	
Presence of vehicles		Dissolved Oxygen (DO):	PH:
Recycle bins		Nitrite:	Nitrate:
Showers		Ammonia:	Phosphate:
Bathrooms		Fecal coliforms:	Turbidity:
Food services			
Parking		OTHER IMPORTANT INFORMATION OBSERVED:	
Dune protection structures			
Accessibility for wheelchair user			

Figure 6. Field sheet for data recording during coastal monitoring excursions, based on the Brazilian Monitoramento Mirim Costeiro programme.

Results and discussion

During the focus group meetings with the 26 participating classes, students universally reported ($n = 26$) that they: a) enjoyed the experience; b) perceived the importance of their activities; c) felt motivated to participate in the programme; and d) appreciated the opportunity to learn in a practical and scientific manner. The beach visits and hands-on scientific activities emerged as the most impactful aspects of their experience.

Students' feedback revealed several key elements characterising their engagement with the model's activities. A word cloud was generated to visually represent these elements, with the size of

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Figure 7. Categorisation of key elements derived from students' feedback, forming the basis for analysing educational experiences.

each term proportional to its frequency in student narratives. The terms "discovery," "novelty," and "surprise" were most prominent, followed by "pleasure/fun" and "perspective opening" (see Figure 7). For the content analysis, five categories were created combining these key elements by similarity, such as "Discovery/Surprise/Novelty," "Protagonism," "Pleasure/Fun," "Opening of Perspective/Purpose," and "Reflection/Correlations". Each category was exemplified by students' quotes and systematised in Table 1, elucidating the significant impact of these key elements on the educational experience.

These key elements, identified through the students' experiences with the model's activities, serve as pivotal motivational tools to boost student engagement in ocean citizenship projects at schools. They combine aspects that stimulate children's interest, curiosity, critical thinking, awareness, behaviour change and connection with their natural surroundings, consistent with the aims of ocean citizenship. The students' scientific explorations beyond the classroom, filled with new discoveries and enjoyment, coupled with the inherently lively and dynamic learning environment provided by the beach, underscore the immense potential of such activities to cultivate student involvement, interest and skill development. Supporting evidence from various studies in ocean literacy across different educational settings (Baldrighi et al., 2022; Chen & Tsai, 2016; Freitas et al., 2023; Mokos et al., 2020; O'Brien et al., 2023; Winks et al., 2020) highlights the critical role of experiential and tangible learning in effectively engaging students. These approaches not only enhance their emotional connection with the marine environment but also foster the development of ocean citizenship competencies. Thus, enriching educational experiences, as provided by the pedagogical model to students, is crucial for advancing holistic and transformative education in ocean literacy and citizenship.

According to the systemic approach systematised by Schio and Reis (2024), the more enriched, diverse and contextually integrated the educational experience, the higher its capacity to resonate with learners, drawing them into addressing the challenges prevalent in their daily environments. The learning environment should evolve into a creative realm where learners, driven by curiosity and environmental challenges, proactively acquire knowledge through dynamic interactions with their surroundings (Alves, 2002; Maturana, 2009). This interaction is seen as a formative encounter with the world around them (Silva, 2008). Moraes (2004) posits that such experiences not only fortify the individual's character, fostering confidence and security but also enhance life quality by making experiences enjoyable and meaningful, thereby cultivating essential skills for both personal development and humanity's advancement.

During the focus groups, students most fondly recalled moments of digging, sifting and discovering objects in the sand (62%, $n = 16$), collecting beach litter (38%), conducting water

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Table 1. Quotes from students highlighting key elements of their experience, systematised into five categories

Categories	Description	Examples of student quotes
Discovery/ Surprise/Novelty	Enthusiasm for new facts about the ocean, emphasising the novelty of practical activities.	*"I learnt that sand is made of minerals, and I didn't know that black sand is magnetic."* *"Seeing the sand under the microscope was really cool, it looked like a diamond!".* *"I really enjoyed it because it was an activity I'd never done before."* *"I really enjoyed it, I ended up finding things I never thought I'd have on the beach."*
Protagonism	The feeling of being actively involved and being the leading actor in the activities.	*"I really felt like a scientist messing around in the sand. We made squares and discovered the rubbish inside and also the natural things."* *"I liked having the experience of doing the activity myself."* *"It was good because now we know more things, we know the beach better, and when we go with a friend of ours, and they don't know what we study, we can teach them."*
Pleasure/ Fun	Perception of the activities as educational and also fun, contributing to positive engagement.	*"I liked everything because I thought it was a fun and enjoyable activity. You can learn and have fun and also help out."* *"Everything was fun: working on the squares, removing rubbish from our area, experimenting with water, the wind rose, observing birds and crabs, but I liked lunch the most because it was sweets day."*
Openness of perspective/ Purpose	Greater awareness of the importance of preserving the ocean, indicating a change in perspective.	*"It was very interesting because we learnt that taking care of our beach is a way of helping our planet."* *"We have to preserve the sea, the sea is essential for life, if there is no life then there are no other things".* *"I thought this project was important because this way we can see how much pollution we humans create on land and in the sea."* *"It was important because we ended up removing rubbish and now we know that there is this problem on the beach. Also, because we analysed the water, learnt more about the beach and the sea, and we made a compass in the sand. We like investigating the sand".*
Reflection/ Correlations	Reflections on the impact of human actions on the ocean, fostering the ability to make important connections and behaviour change.	*"Sometimes people pick up a microplastic and imagine . . . ahhh it's just plastic, it won't do any harm . . . they don't realise that tiny little thing has an impact . . . then imagine, we can't have any more fish, because the fish could all die because of the plastics, because the animals in the sea think it's their food, but it's plastic."* *"We pick up rubbish from the beach, so it doesn't get so polluted, and it helps that the rubbish doesn't end up in the sea with the wind or the tide."* *"We kill animals with microplastic, and people don't realise that they're contaminating their own food."*

analysis experiments (38%, $n = 19$), creating wind roses (31%, $n = 8$) and investigating their environment (23%, $n = 6$) (Figure 8). The exploration of the sand was the most mentioned aspect by the students, highlighting their motivation and curiosity to explore and find objects in the sand. Additionally, the use of microscopes stimulated the association of the sand formation process and its mineralogical composition, as exemplified in the student quotes in Table 1. By magnifying the sand grain under the microscope, the students not only realised that sand is composed of rock crystals but were also captivated by the beauty of the crystals — "It looked like a diamond!" — and their imagination was sparked by the shapes of the grains: "When I looked at the sand under the microscope, it looked like a cave."

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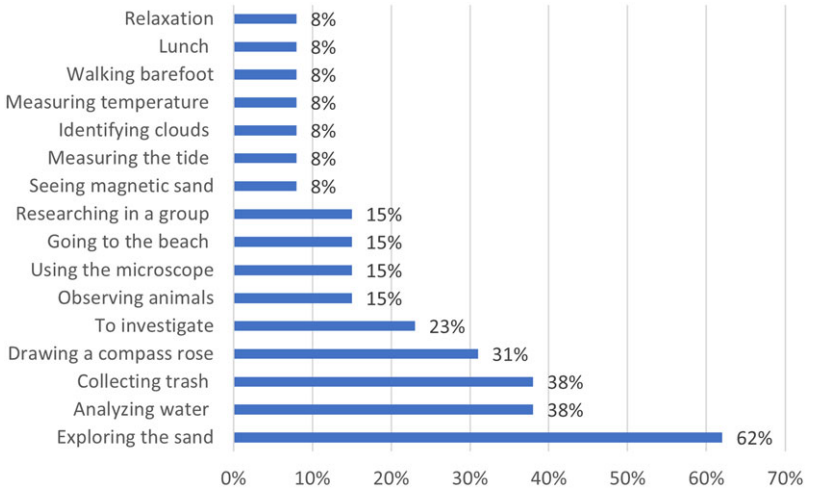

Figure 8. Overview students' favourite moments.

This feedback underscores the motivational power of practical and scientific tasks in stimulating learning and environmental consciousness. Rubem Alves (2002) suggests that intelligence is inherently practical, and knowledge acquired through life-enhancing activities is enduring, becoming ingrained within us. Engaging with the world outside traditional classroom confines is essential, as it stimulates the senses, emotions and intellect, exposing learners to experiences beyond their daily reality, a cornerstone of *Transdisciplinary Educational Experiments* (Matarezi, 2005).

Utilising research tools to explore the coastal environment not only equipped students with new skills through investigative activities but also sparked discoveries that fuelled their interest, curiosity and motivation. Significant to their learning experience was the broadening of perspectives on the studied environment and a reflective consideration of observed challenges. For instance, the task of collecting rubbish emerged as a particularly meaningful activity, highlighting students' recognition of their contributory role in ocean and planetary stewardship, thereby serving as a powerful motivator and engaging factor.

Paulo Freire (2011) underscored the significance of anchoring learning in meaningful themes derived from life experiences, advocating for education that is deeply rooted in and reflective of the sociocultural realities of the learner's community. Such enriched learning experiences prompt individuals to critically reassess their practices and address life's challenges in a more integrated and systemic manner. This evolved perspective and emotional resonance with the world around them invariably influence behavioural and attitudinal shifts, propelling individuals towards purposeful action.

Tonso (2005) highlights that if we want to transform our students, we have to "touch" them, highlighting the integral role of affectivity in learning. The student quotes in Table 1 express their motivation and enjoyment in exploring the beach and discovering new things they never knew before, as well as their desire to clean and protect the environment after observing pollution problems that harm the ecosystem. Their expressions of feelings support the importance of creating educational experiences that reinforce emotional connections with the environment, which is essential if we want to foster a generation that is aware and committed to a more sustainable way of life. This view is supported by Maturana (2001), Moraes (2004) and Morin (2011), who emphasis the pivotal influence of emotions and feelings in shaping human competencies, actions and behaviours. McKinley and Fletcher (2012) further advocate for nurturing an awareness and understanding of marine issues, emphasising the need for a shift in values towards assuming personal responsibility for the marine environment.

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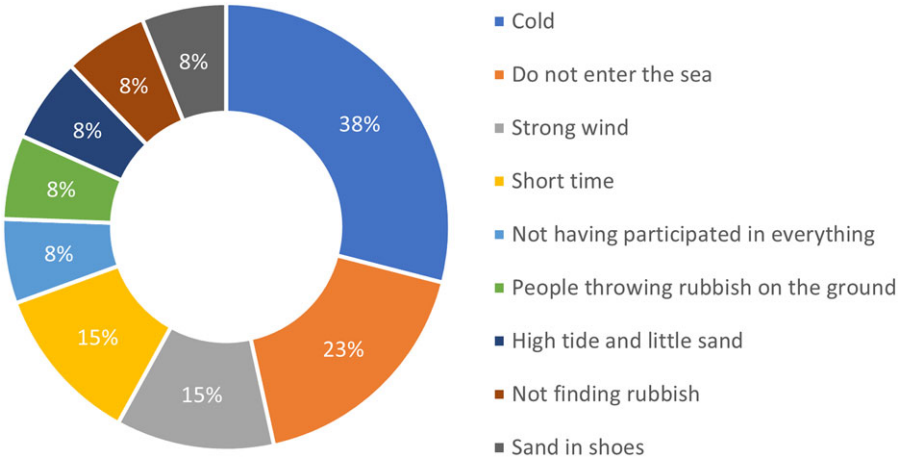

Figure 9. Systematisation of less favoured moments as reported by students.

Hence, fostering ocean citizenship committed to marine conservation necessitates educational experiences that not only educate but also emotionally engage individuals, deepening their connection to the sea. This approach, aimed at redefining the human–ocean relationship, calls for more opportunities for interaction and emotional involvement with the marine world, enriching the learning experience with moments of joy, discovery and profound learning.

During the 26 focus group sessions, students shared aspects of the experience they found less enjoyable. Notably mentioned were the adverse weather conditions encountered during field trips — cold (38%, $n = 10$), strong wind (15%, $n = 4$) and very high tide (8%, $n = 2$) — alongside a perceived shortage of leisure time (15%, $n = 4$) and a longing to enter the sea (23%, $n = 6$) (Figure 9). Despite understanding the scientific nature of these excursions, many expressed a strong desire to get into the sea, a sentiment stemming perhaps from their infrequent visits to the beach, despite residing in coastal areas. Addressing this gap, one teacher organised a visit to a calm, monitored beach towards the academic year's end, enabling students to safely swim in the sea, thereby enriching the educational impact and fostering deeper connections with the marine environment.

Further feedback highlighted constraints in participation and engagement, particularly during initial activities like weather condition assessments, where the collective task led to periods of inactivity for some students. This contrasted with more hands-on tasks like sand exploration in the squares, which kept students engaged with individual research tools. Such moments underscore the importance of active participation in maintaining student motivation and interest. Some students mentioned that they didn't like finding a lot of rubbish on the beach, and even more so because they had seen a person throwing rubbish on the ground. Others mentioned the opposite, that they didn't like not finding any rubbish, as they found few objects to explore in their research squares. This divergence underscores the complexity of environmental education, where even the absence of pollution can serve as a powerful teaching moment about conservation success.

Students provided valuable suggestions to enrich future activities, emphasising a desire for a more immersive and extensive exploration of marine environments. Their proposals included: a) increasing the number of research squares and extending the monitoring to diverse beach areas; b) scheduling activities during low tide to maximise sand exposure; c) creating quizzes for inter-school engagement; d) incorporating diving masks for underwater rubbish collection; e) including opportunities for swimming; f) exploring various beaches; g) allotting more time for activities; h) organising boat trips; and i) distributing scientist coats to participants. The desire expressed by one student to own a scientist's coat and the interest of another in receiving a microscope for

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Table 2. Student recommendations for coastal environmental improvement

Categories	Examples of student quotes
Rubbish disposal	*"I think they should put containers of each colour, because you often get to the beach and only see the ones of one colour, for example, the most common is the green one that you put everything in."* *"Concerning cigarette butts, we could put in more special rubbish bins, which can be put out and put back in."* *"One of the things I saw on the beach is that there are rubbish bins and people put their rubbish on the ground, and people who are further away from the bins could take a bag from home to put their rubbish in."*
Practical actions	*"Whenever we go to the beach with my mom we take a bag for us to put the rubbish in. Like if we see rubbish flying, we run after it."* *"We could do a project where all the classes go to the places and pick up some rubbish."* *"There could be a fine for people who throw rubbish on the ground."* *"If we saw someone throwing rubbish on the ground, they would have to pick it up, but they would also have to help clear the rubbish from the beach."* *"We can think more about the products we buy in the market, which have less packaging. Sometimes we buy a magazine with the little letters in the bags and then it turns into a pile of rubbish that gets thrown away."*
Communication	*"Take a photo of the area that no longer has rubbish and warn people not to do it again, to throw things away."* *"We could put up a sign saying to preserve the beach more, as we've been finding a lot of rubbish, and for people to help too, especially by the sea."* *"Right at the entrance to the beach, we could put up a sign saying not to throw rubbish on the ground, so as not to dirty the beach."* *"They could put an arrow for the rubbish to indicate where it is."* *"I think we could take a poster, and instead of the animals being full of plastic and things, it would be the humans; instead of the animals, it would be the humans suffering."* *"We can put some of the things we're doing on the school blog".*
Partnerships	*"In the summer, we could go to the café areas and do a swap campaign. If people brought their rubbish, they could swap it for something else."*

Christmas underscores the profound motivational impact of these experiences, affirming their potential to inspire youth towards marine-related careers (IOC-UNESCO, 2022).

Research by Garcia-Vazquez, Garcia-Ael, Mesa, Dopico, and Rodriguez (2022) and Guest et al. (2015) corroborates the link between ocean engagement and marine conservation awareness. These studies highlight that direct interaction with the marine environment enhances ocean literacy, fosters a deeper appreciation for the marine ecosystem and stimulates interest in marine-related professions. Moreover, emphasising the emotional aspects of ocean citizenship could significantly influence behaviours, such as reducing single-use plastic consumption and promoting eco-friendly alternatives (Garcia-Vazquez et al., 2022).

Adopting uniforms, accessories, and providing hands-on sea experiences serve as powerful strategies to kindle the exploratory spirit in young individuals, moulding them into proactive stewards of their coastal environments. According to Santos and Costa-Pinto (2005), it is precisely these experiences that amplify an individual's capacity to effect change, paving the way for transformative actions rooted in a profound understanding of environmental stewardship.

To address observed coastal challenges, students suggested practical measures including: 1) installing additional waste bins, specifically for cigarette butts and recyclables; 2) erecting signage to discourage littering; 3) launching educational campaigns with local business participation during peak seasons; 4) enhancing visibility of programme achievements through school blogs and social networks; 5) enforcing littering penalties with the aid of security personnel; and 6) organising more beach cleanup events. These recommendations are categorised under "Garbage Disposal," "Practical Actions," "Communication," and "Partnerships," as depicted in Table 2.

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These insights not only reflect the students' commitment to addressing marine pollution but also their capacity for critical thinking and solution-oriented approaches to environmental challenges.

The suggestions from students reveal a rich tapestry of ideas and actionable insights, showcasing the emergence of critical thinking, activism and ocean citizenship cultivated through their educational journey. These insights, when effectively bridged among schools, public authorities and local communities, possess immense potential for real-world application, promising significant, positive changes within communities. McKinley and Fletcher (2012) highlight the pivotal role of citizens, especially young learners, in assuming active roles for enhanced governance and marine conservation.

Discussions within the focus groups illuminated how students, influenced by their educational experiences, have begun to alter their daily habits and those of their families, underpinning a genuine commitment to ocean preservation: *"Once, I was walking with my grandmother and she threw some trash on the ground. Immediately, I picked it up and explained to her that the trash could eventually end up in the sea and harm the animals."*. This grass roots level of engagement suggests a powerful avenue for fostering environmental awareness and action through a *bottom-up* process, characterising students as key agents of change in their families and broader communities.

According to Squarcina and Pecorelli (2017), one approach in which the concept of citizenship has been applied is through a personal disposition that motivates individuals to act by contributing to the common good of their community and seek territorial improvements. Developing awareness of how our daily choices, both individual and collective, impact the oceans, and fostering behavioural changes to support their preservation, are essential traits of ocean citizenship. This also involves recognising our rights and responsibilities towards this common good (McKinley, 2010).

The students' narratives express various aspects found in the pedagogical model's set of competencies and the literature (Buchan et al., 2023; Fletcher and Spotts, 2007; Mckinley & Fletcher, 2012; Mckinley, 2010) that are essential for developing ocean citizenship. These aspects include acquiring new knowledge, cultivating values of respect and care for the ocean, developing skills to act in favour of ocean preservation and becoming more aware of their role as agents of change.

The educational activities within the pedagogical model not only fostered the development of new competencies in the students but also addressed the actions anticipated in each model dimension, as well as the range of tools selected by Schio and Reis (2024) to foster ocean citizenship initiatives (Figure 10). These outcomes affirm the model's applicability and its potential to promote ocean citizenship in basic education. However, it was observed that certain aspects, particularly the activism dimension, require further emphasis. While students reported personal behavioural changes, they lacked examples of direct actions addressing the observed coastal issues. Consequently, developing strategies to bolster this dimension is crucial, encouraging students, teachers and the entire school community to undertake tangible interventions to address the challenges facing their coastal zones.

The coastal monitoring project culminated in a celebratory videoconference among the participating schools, marking the end of the school year. This event was charged with enthusiasm as students from all 26 classes showcased the diverse and impactful work conducted across various Portuguese coastal regions. Each class shared a three-minute video highlighting their activities, findings and personal reflections on their commitment to ocean preservation. The culmination of this event was the presentation of personalised certificates to each student, honouring their contributions as ocean monitors and ocean guardians.

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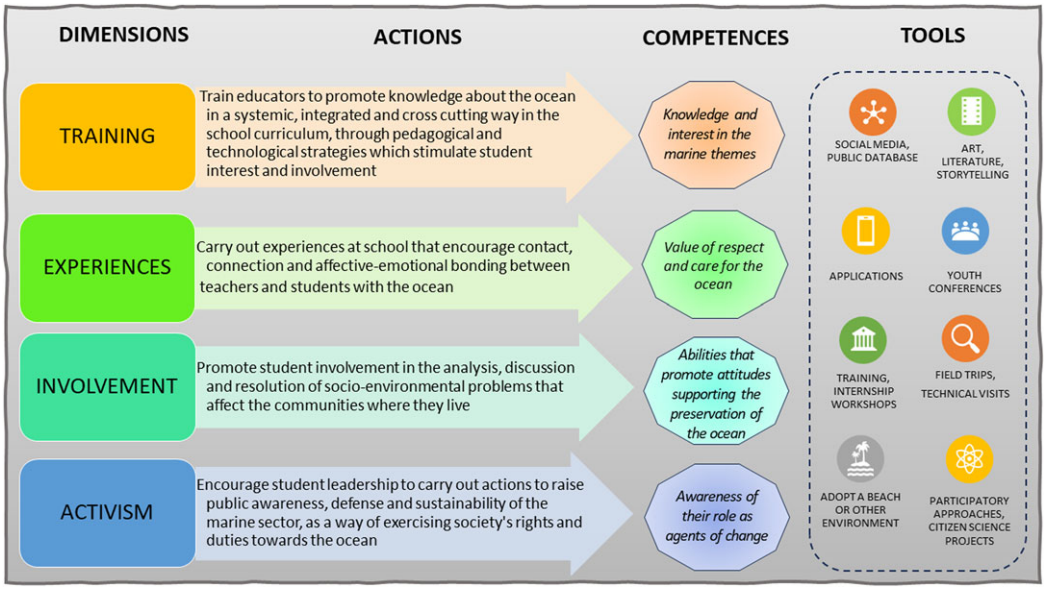

Figure 10. Dimensions, actions, tools and competencies that structure the conceptual base of the pedagogical model (Schio & Reis, 2024, p.13).

The presentations revealed a wide spectrum of interdisciplinary work undertaken throughout the year, integrating the project's themes across various subjects, as shown in the diagram in Figure 11 and illustrated in Appendix I. This approach not only demonstrated the pedagogical model's transdisciplinary nature but also emphasised the collaborative potential among educators to engage in cohesive and complementary educational efforts. This methodology aligns with Brennan et al. (2019), who advocate for using System Dynamics simulations to enhance ocean literacy, emphasising the importance of cross-curricular integration for a more holistic understanding of marine issues.

The model's emphasis on extracurricular activities, coastal visits and the cultivation of social and emotional connections with the sea, alongside promoting activism and ocean citizenship, mirrors the IOC-UNESCO (2022) proposal for blue school curriculum development. Such alignment suggests that the pedagogical model not only adheres to but advances the goals set forth by the Ocean Decade (IOC-UNESCO, 2021) and Education for Sustainable Development, particularly SDG 14: "Protect the oceans and marine resources through ocean literacy and action" (UNESCO, 2020) (p. 17).

Figure 12 displays a diagram summarising indicators of the key outcomes of students' experiences with the pedagogical model's educational activities. These outcomes not only highlight the emergence of new competencies in students, fostering essential skills and attitudes towards ocean conservation, but also demonstrate the model's potential to promote ocean citizenship in basic education.

Considering the ten dimensions of ocean literacy outlined by McKinley et al. (2023), the evaluation of the pedagogical model through students' experiences has shown promising coverage across most areas, as illustrated in Table 3, highlighting the model's multidimensional approach. However, activism was identified as an area needing further emphasis, particularly in encouraging

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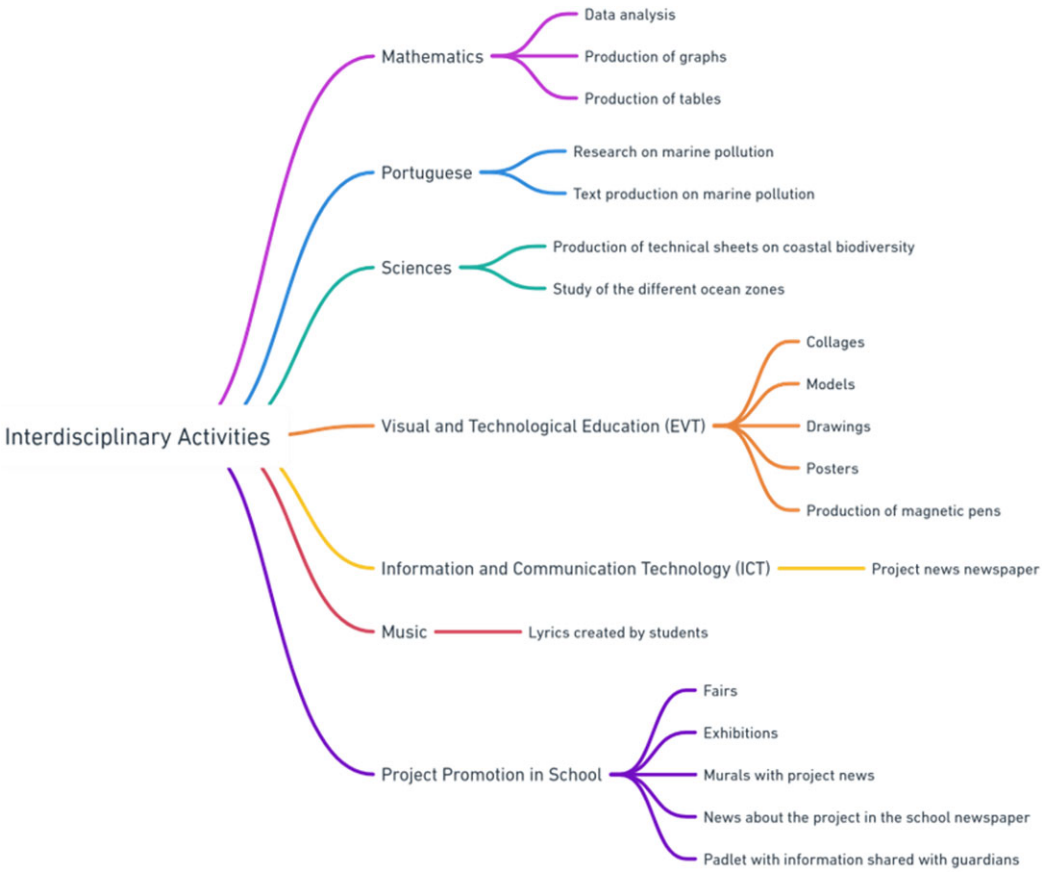

Figure 11. Diagram of interdisciplinary activities carried out by students throughout the school year.

students to implement their suggested ideas. The dimension of adaptive capacity was challenging to correlate with students' experiences, but potential correlations could be explored in the future with longer-term monitoring of the pedagogical model's impact. As this remains a pilot project, further implementation in diverse educational settings is necessary to gather more specific and robust data to substantiate these findings.

Although the pedagogical model has demonstrated significant potential for adoption by schools and for promoting ocean citizenship in primary education, its full effectiveness will only be realised after several design cycles and necessary refinements. Furthermore, it is essential to consider the suggestions mentioned by the students to maximise the impact of the educational experience, especially those experiences that strengthen the students' bond and emotional connection with the sea.

Conclusion

The testing of the pedagogical model with 543 students from 26 5th and 6th-grade classes (children aged 10 and 11) allowed us to verify the emergence of new knowledge, skills, values, critical thinking and attitudes, reflecting the development of ocean citizenship competencies

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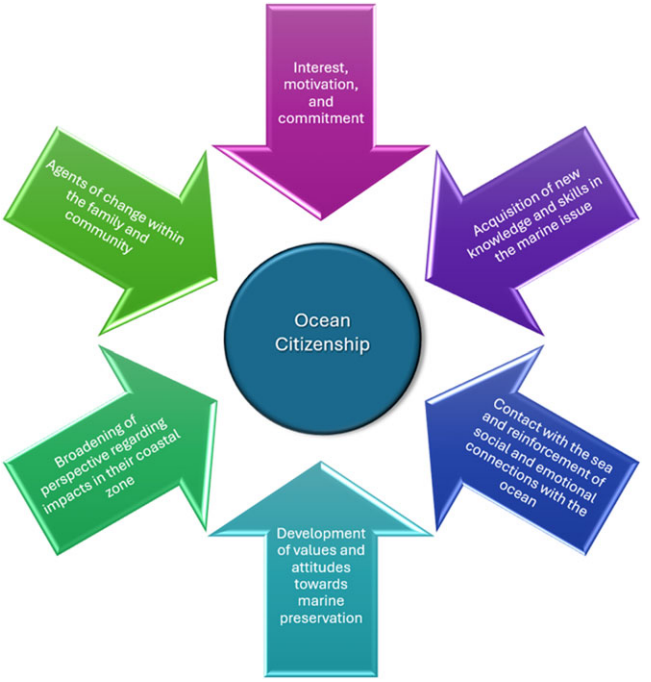

Figure 12. Indicators of the key outcomes of students' experiences, highlighting the potential of the pedagogical model to promote ocean citizenship in basic education.

Table 3. Correlation between the results of the pedagogical model and the ten ocean literacy dimensions outlined by McKinley et al. (2023)

McKinley et al. (2023)'s O.L dimensions	Alignment with pedagogical model results
Knowledge	Students developed new knowledge and skills through practical activities that connected theory with real-world ocean contexts.
Awareness	Students became more aware of local and global ocean issues, as well as practical solutions in their community, fostering a sense of responsibility among them.
Attitude	The experience fostered a positive shift in students' perspectives, values and attitudes towards ocean conservation and sustainability.
Behaviour	Students engaged in positive behaviours, such as collecting litter and making other attitudinal changes in their daily lives, demonstrating greater environmental responsibility.
Activism	While students reported personal behavioural changes, they lacked examples of direct actions addressing the observed coastal issues. This indicates that the dimension of activism needs further emphasis, encouraging students to take more concrete actions and engage in advocacy.
Communication	Students shared their results and findings both within the school and with their communities, raising collective awareness.
Emotional Connections	Practical and immersive activities helped strengthen students' emotional connections with the marine environment, fostering greater empathy and motivation for conservation.
Access and Experience	Direct access to the marine environment was facilitated through field activities, providing students with meaningful and engaging hands-on experiences.
Adaptive Capacity	Although difficult to correlate in the short term, there is potential to explore the development of adaptive capacity over time through ongoing monitoring of the model's impacts.
Trust and Transparency	Students' active participation in all project stages ensured transparency and trust in the information, as they were directly responsible for data collection and analysis. This reinforced trust in information sources and the integrity of the research process.

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among students. The practical, exploratory and participatory aspects of the model's activities have demonstrated the significant potential of such projects to stimulate students' curiosity, motivation, protagonism and engagement in ocean conservation. Investigating the coastal environment not only allowed students to develop new competencies through scientific activities but also led to new discoveries, broadened perspectives and critical reflection on the current challenges related to ocean sustainability and our role as agents of change.

By promoting extracurricular activities, coastal visits, social connections with the sea, and fostering activism, protagonism, and ocean citizenship in basic education, the proposed pedagogical model encompasses characteristics identified by IOC-UNESCO (2022) as essential for developing a blue school curriculum. This pedagogical experience confirmed not only the viability of the proposed model, but also its potential to integrate ocean citizenship in basic education, in line with the goals of the Decade of the Ocean and the UN's 2030 Agenda. However, it was observed that the activism dimension requires additional emphasis in order to reinforce the importance of schools promoting actionable interventions in their local community.

Furthermore, it would be interesting to test the pedagogical model in different school environments and contexts, namely schools inland or without access to the sea, in island environments or in other aquatic environments such as rivers, lagoons, etc. This iterative approach will make it possible not only to refine the model, but also to obtain more robust evidence of its effectiveness. In addition, incorporating students' perceptions and suggestions into the model's evolution process is fundamental to enhancing the educational experience, strengthening their social connections with the sea and making ocean citizenship education a key element in nurturing a more aware generation engaged in protecting the oceans.

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Ethical standards. The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Instituto de Educação, Universidade de Lisboa (on the 26 of January 2022).

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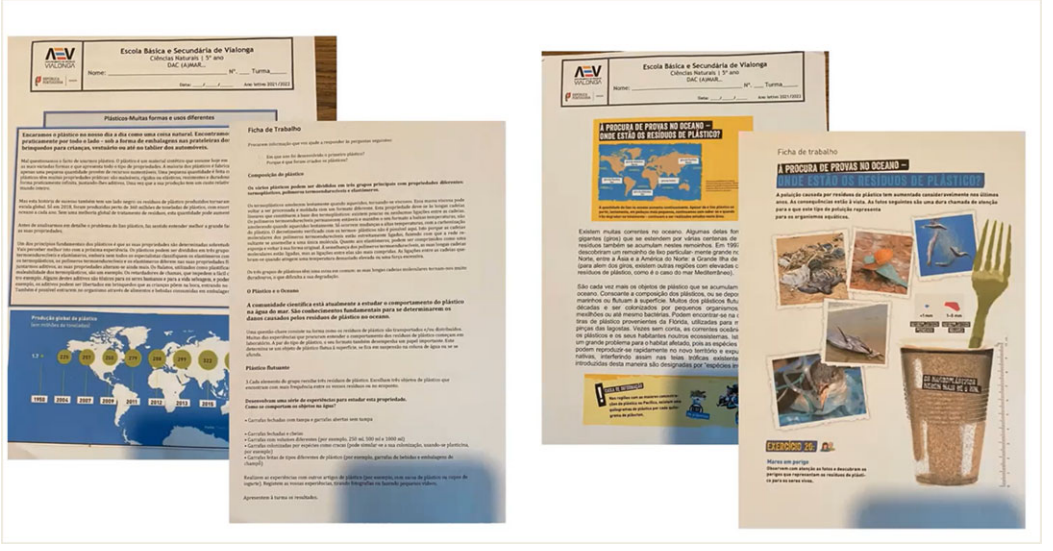
Appendix 1 – Examples of interdisciplinary work carried out by teachers

Maths — analysing data, producing graphs and tables.



Portuguese — research and production of a text on marine pollution.

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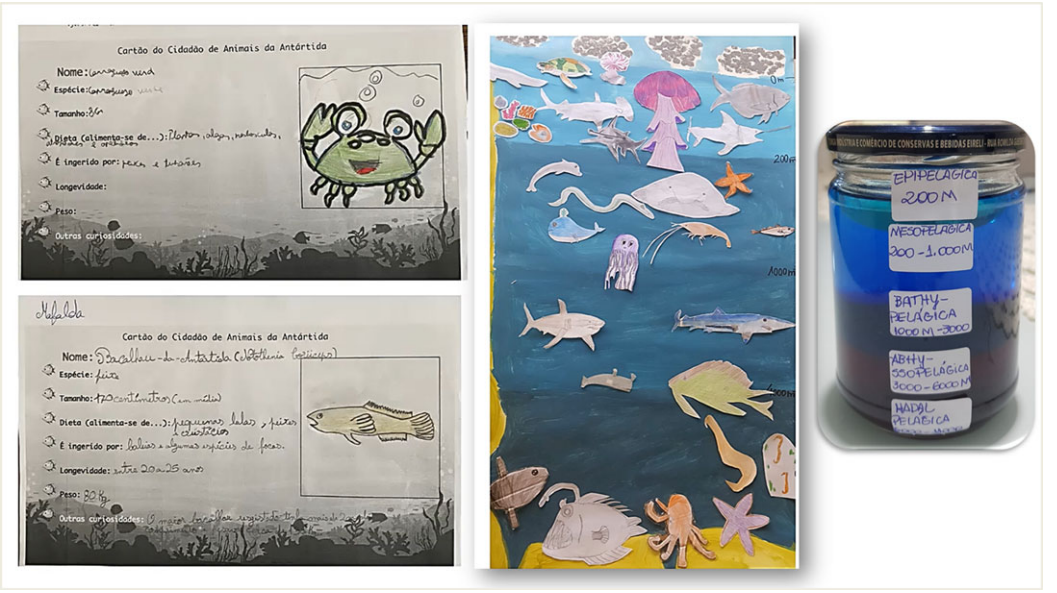

Science — Production of factsheets on coastal biodiversity and the different zones of the ocean.

Visual and Technological Education (VTE) — Collages, models, drawings, posters, and the production of magnetic pens.

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Information and Communication Technology (ICT) — Project news journal.

Publicising the project at school — Fairs, exhibitions, murals with project news.

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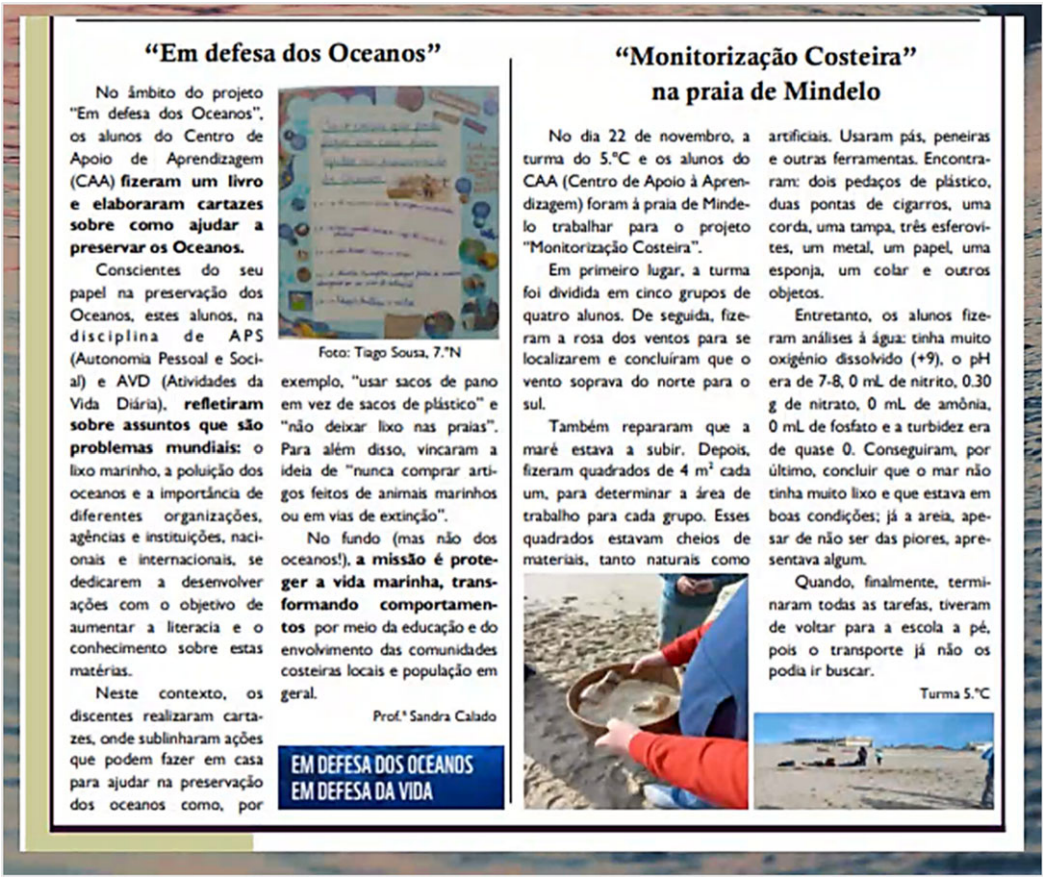


"Em defesa dos Oceanos"

No âmbito do projeto "Em defesa dos Oceanos", os alunos do Centro de Apoio de Aprendizagem (CAA) **fizeram um livro e elaboraram cartazes sobre como ajudar a preservar os Oceanos.**

Conscientes do seu papel na preservação dos Oceanos, estes alunos, na disciplina de APS (Autonomia Pessoal e Social) e AVD (Atividades da Vida Diária), **refletiram sobre assuntos que são problemas mundiais:** o lixo marinho, a poluição dos oceanos e a importância de diferentes organizações, agências e instituições, nacionais e internacionais, se dedicarem a desenvolver ações com o objetivo de aumentar a literacia e o conhecimento sobre estas matérias.

Neste contexto, os discentes realizaram cartazes, onde sublinharam ações que podem fazer em casa para ajudar na preservação dos oceanos como, por exemplo, "usar sacos de pano em vez de sacos de plástico" e "não deixar lixo nas praias". Para além disso, vincaram a ideia de "nunca comprar artigos feitos de animais marinhos ou em vias de extinção".

Foto: Tiago Sousa, 7.ºN

No fundo (mas não dos oceanos!), **a missão é proteger a vida marinha, transformando comportamentos** por meio da educação e do envolvimento das comunidades costeiras locais e população em geral.

Prof.ª Sandra Calado

EM DEFESA DOS OCEANOS
EM DEFESA DA VIDA

"Monitorização Costeira" na praia de Mindelo

No dia 22 de novembro, a turma do 5.ºC e os alunos do CAA (Centro de Apoio à Aprendizagem) foram à praia de Mindelo trabalhar para o projeto "Monitorização Costeira".

Em primeiro lugar, a turma foi dividida em cinco grupos de quatro alunos. De seguida, fizeram a rosa dos ventos para se localizarem e concluíram que o vento soprava do norte para o sul.

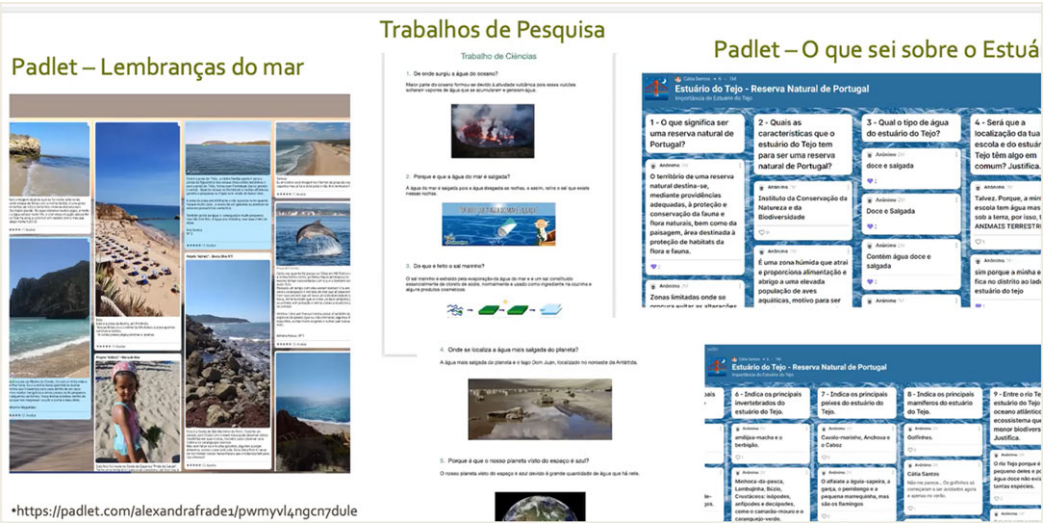
Também repararam que a maré estava a subir. Depois, fizeram quadrados de 4 m^2 cada um, para determinar a área de trabalho para cada grupo. Esses quadrados estavam cheios de materiais, tanto naturais como artificiais. Usaram pás, peneiras e outras ferramentas. Encontraram: dois pedaços de plástico, duas pontas de cigarros, uma corda, uma tampa, três esferovites, um metal, um papel, uma esponja, um colar e outros objetos.

Entretanto, os alunos fizeram análises à água: tinha muito oxigénio dissolvido (+9), o pH era de 7-8, 0 mL de nitrito, 0.30 g de nitrato, 0 mL de amônia, 0 mL de fosfato e a turbidez era de quase 0. Conseguiram, por último, concluir que o mar não tinha muito lixo e que estava em boas condições; já a areia, apesar de não ser das piores, apresentava algum.

Quando, finalmente, terminaram todas as tarefas, tiveram de voltar para a escola a pé, pois o transporte já não os podia ir buscar.

Turma 5.ºC

Publicising the project at school — News about the project in the school newspaper.



Publicising the project — Padlet with information shared with parents.

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Author Biographies

Caroline Schio holds a degree in Oceanography from the University of Vale do Itajaí, Brazil (2007), a postgraduate qualification in Fisheries Economics and Management from the University of Barcelona (2009), and a Master's degree in Agroecosystems from the Federal University of Santa Catarina (2015), Brazil. She is currently pursuing a PhD in Science Education at the University of Lisbon. With over 12 years of experience leading the Monitoramento Mirim Costeiro Program for elementary school students, Caroline has also served as the president of the Monitoramento Mirim Costeiro Institute for 5 years and has spent 2 years contributing to the Maçarico Ocean Literacy program with Colab + ATLANTIC in Portugal.

Pedro Reis holds a PhD (2004) and a Master of Education (1997) from the University of Lisbon, as well as a Bachelor's degree in Biology (1988) from the same institution. Before becoming a professor, he worked as a science teacher in elementary and secondary schools. Currently, he coordinates the Research Group on Didactics at the Institute of Education, University of Lisbon, where he also leads the PhD program in Science Education and the Master's program in Innovation in Education.

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