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SciELO

Ocean as an interdisciplinary theme in Brazilian basic education

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Abstract: There is a great lack of scientific knowledge about the Ocean and a disconnect between scientific knowledge and public understanding of this environment. Considering the importance of Ocean Literacy in society, we illustrate in this study how the complexity and transversality of the Ocean enable disciplinary and interdisciplinary dialogues and reflections in schools. Based on a documental analysis, this work identified the presence and frequency of relationships between the Specific Competencies (SC) of the Common National Curriculum Base (BNCC - High School) and the Ocean Literacy Principles, based on contents of the Natural Sciences. Relationships between all the Principles and SC were identified, favored by aspects such as interdisciplinarity, scientific work, social dimension and complexity. Considering the illustrative character of this work, we emphasize the potential of using the Ocean as an integrating theme, the need for educational processes for educators and the planning of school pedagogical proposals.

Keywords: Science teaching; education for sustainability; formation for citizenship; systemic thinking; SDG 14.

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Introduction

Since approximately 3.9 billion years, the Ocean has interacted with the Earth's crust through changes in sea level that alter coastlines and create or open seas (NOAA, 2013). The Ocean contains 97% of the planet's water; influences the water cycle and the formation of rainfall; it has a great capacity to absorb atmospheric CO_2, contributing to the regulation of planetary temperature (BOLLMANN et al., 2010; NASA, 2017); provides a huge amount of ecosystem goods and services such as food, medicine, minerals, energy, recreation and inspiration (BEIRÃO; MARQUES; RUSCHEL, 2020; NOAA, 2013). More than 1.3 billion people live in cities less than 100 km from the coast in tropical regions and many depend on the sea for food and survival (ONU, 2021; SALE et al., 2014). For Brazil, the Ocean represents about 19% of the Gross Domestic Product (CARVALHO, 2018).

Despite all its importance, currently more than 59% of the Ocean is highly affected by impacts derived from human activities, such as overfishing and pollution, in addition to the effects of global climate change (HALPERN et al., 2019; IPBES, 2019).

Recognizing the necessity of further understanding the Ocean, the United Nations (UN) has established the Decade of Ocean Science for Sustainable Development, spanning from 2021 to 2030. The primary objective of this initiative is to encourage researchers, governments, and civil society to advance their knowledge of the Ocean and develop strategies to promote its conservation and sustainable utilization (IOC/UNESCO, 2019).

In addition to the still great lack of scientific knowledge about the Ocean, there is a disconnect between what scientists know and what the public understands about this environment (FLETCHER et al., 2009; RUSSONELLO; STEWART; AMERICAN VIEWPOINT, 1999; SEYS et al., 2008; STEEL et al., 2005). Many social groups, such as decision makers, do not have enough knowledge about the Ocean to be able to formulate public policies to promote its sustainable use (UYARRA; BORJA, 2016). Likewise, low levels of knowledge can be a barrier for citizens to adopt environmentally responsible behaviors or even consider pursuing ocean-related careers (GREELY, 2008; PLANKIS; MARRERO, 2010; WINKS et al., 2020).

In Brazil, data from a 2011 survey revealed that almost three out of ten people (29%) do not know the sea (CEMBRA, 2012). Of those interviewed in this survey, 73% said they attach great importance to the sea, prioritizing the fact that it is a source of food (67%) and a source of leisure (39%). Other studies in Brazil showed that several people: 1) are unaware of the sea and marine biodiversity, for example confusing corals with sponges or algae and vice versa, or not even considering them as living beings (DOCIO; RAZERA; PINHEIRO, 2009; OIGMAN-PSZCZOL; OLIVEIRA; CREED, 2007; PEDRINI et al., 2010), and 2) have never heard of ocean acidification or changes in hydrodynamics as a result of climate change or believe that these topics are exaggerated by the media and that human beings are capable of dominating all the processes that occur in the sea (BARRADAS; GHILARDI-LOPES, 2020; GHILARDI-LOPES et al., 2015).

"Cultura Oceânica", a Brazilian term for Ocean Literacy, can be interpreted as an initiative for the various actors in society to recognize the importance of the Ocean in

our lives, perceive our influence on this environment, think about behaviors and propose actions, public policies and innovative tools that help to conserve it and guarantee the quality of life of future generations (GHILARDI-LOPES; KREMER; BARRADAS, 2019; INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION, 2021). Despite the formalization of the term in Brazil only in 2019, there were already several initiatives related to the subject in the country, promoted by different institutions (GHILARDI-LOPES; BERCHEZ, 2019), in addition to the Brazilian Navy's Maritime Mentality Promotion program that has existed since 1997 (CEMBRA, 2012).

In addition to its importance for humanity, the "Ocean" theme holds significant pedagogical potential for organizing school contents and fostering disciplinary and interdisciplinary discussions and reflections. This potential arises from the fact that socio-environmental issues related to the Ocean have multiple dimensions, including geographic, historical, physical, biological, political and social (LEVIN; POE, 2017).

Within this context, including the Ocean theme in school curricula can equip the next generation of citizens, scientists, managers, educators, and leaders with the necessary knowledge and skills through educational opportunities. Moreover, integrating this theme into schools that are located far from the coast can offer an important context for classes and demonstrate that everyone bears responsibility for maintaining the quality of marine environments (LEBRETON et al., 2017). Therefore, it is necessary to subsidize the propositions of the curricula and the formation and performance of managers and educators.

For this, one strategy is to highlight the relationship that the theme has with official documents, such as the National Common Curricular Base (BNCC), which assists in the production of curricula in Brazilian schools. Recent studies (MAURÍCIO; DUARTE; SILVA, 2021; PAZZOTO et al., 2021), emphasized the underrepresentation of terms related to Ocean Literacy in the BNCC and in state curriculum guidelines. Despite this apparent under-representation of the Ocean in the BNCC, the present work considers the hypothesis that the Ocean has, in fact, numerous points of insertion in the BNCC, being able to serve as an integrating axis in the school curricula.

The idea of a National Common Base is present in the Brazilian National Curriculum Guidelines (BRASIL et al., 2013), as a guideline, organization, articulation, development, and evaluation document of the pedagogical proposals that each teaching network would build. Its character of guidance guaranteed the autonomy of schools to produce curricular proposals that were better suited to their contexts. Before the construction of the BNCC, the National Curriculum Parameters of Secondary Education (PCNEM) (BRASIL; MINISTÉRIO DA EDUCAÇÃO, 2006), also had this character of guidance and recommendation. The BNCC originated from Ordinance CNE/CP nº 11/2014 and was ratified in 2018. There are different opinions on the need for a common basis in academic discussions about curricula and its homologation context brought several controversies during an economic, political, and social crisis that took place from 2016 in Brazil. This article does not intend to discuss what curriculum is or the implications of the BNCC, but we agree with Lopes (2018, p. 23) when he establishes some items of criticism of the

document, such as the insistence on an immediate link between education and economic development, the appreciation of the salvationist character of education, the reduction of education to learning levels and the provision of social guarantees that all students will have uniform learning credentials/standards and the assumption that teachers don't know what to do in schools without common curriculum guidance.

Additionally, the BNCC cannot be understood as a curriculum proposal for the States, much less for schools (NEIRA; ALVIANO JÚNIOR; ALMEIDA, 2016). We understand here that the BNCC presents a basic set of competences and skills that can be organized by the schools' pedagogical teams and their teachers to produce their curricula, according to the demands and peculiarities of the realities present in different locations in the national territory.

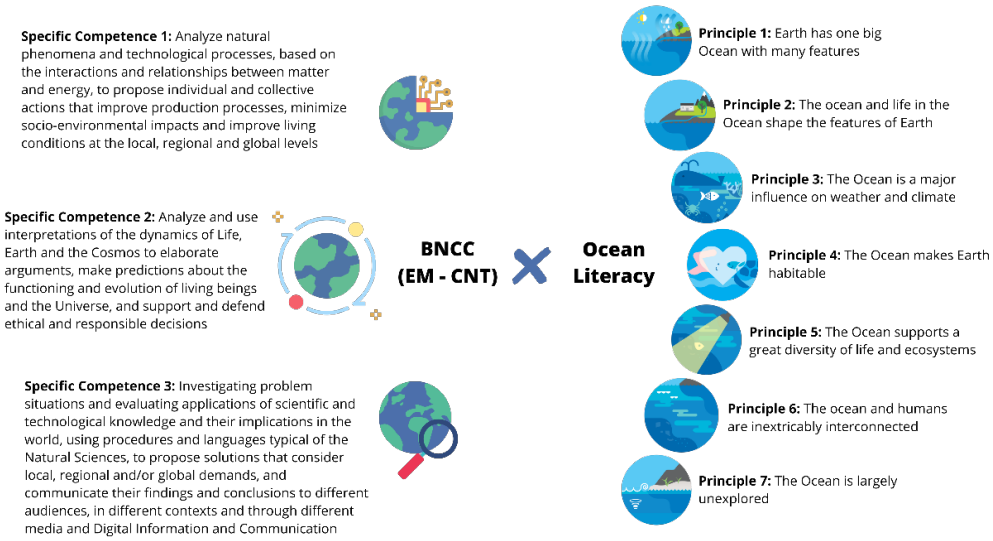
Finally, we consider that the inclusion of the Ocean Literacy theme in school curricula can help in the process of an education committed to the exercise of citizenship and bring the various formative dimensions intended by the BNCC (technical, scientific, cultural, and political). The Ocean Literacy Principles can be used in line with the BNCC, enabling basic education students not only to learn scientific concepts (from different areas of knowledge), but also to carry out political, social and aesthetic discussions that must be addressed critically, as advocated by Freire (1967) and Layrargues (2001).

Within this context, the present work intends to highlight the potentialities of the "Ocean" as an integrative theme in the school, through the analysis of the relationships between the Specific Competences of the Natural Sciences area and its Technologies, proposed by the BNCC (high school stage) (MINISTÉRIO DA EDUCAÇÃO, 2018) and the seven principles of Ocean Literacy.

Methodology

This work followed the assumptions of documental analysis (LÜDKE; ANDRÉ, 1986). With the aim of highlighting potential relationships between the BNCC and Ocean Literacy, the three Specific Competences present in the BNCC document for Natural Sciences and their Technologies in the High School stage (MINISTÉRIO DA EDUCAÇÃO, 2018) and the seven principles of Ocean Literacy (CAVA et al., 2005) were considered (Figure 1). The analysis was refined by considering the Skills related to each Specific Competency (MINISTÉRIO DA EDUCAÇÃO, 2018), as well as the sub-items related to each Ocean Literacy Principle (BARRADAS et al., 2021).

Figure 1 – Specific Competences of the National Common Curricular Base (BNCC) for Secondary Education (EM) - area of Natural Sciences and Technologies (CNT) and Ocean Literacy Principles



Source: elaborated by the authors based on the Ministry of Education (2018) and Santoro et al. (2020). Ocean Literacy icons of Santoro et al. (2020).

Although we understand Ocean Literacy as an integrative theme that can be approached in a transversal and interdisciplinary way, it was decided to use the area of Nature Sciences as a focus in this article. According to the BNCC:

> "*In Basic Education, the area of Natural Sciences must contribute to the construction of a contextualized knowledge base, which prepares students to make judgments, take initiatives, elaborate arguments, and present alternative propositions, as well as make judicious use of different technologies. [...] In High School [...] Students, with greater experience and maturity, are able to deepen the exercise of critical thinking, carry out new readings of the world, based on abstract models, and make responsible, ethical decisions and consistent in identifying and solving problem situations*" (MINISTÉRIO DA EDUCAÇÃO, 2018, p. 537).

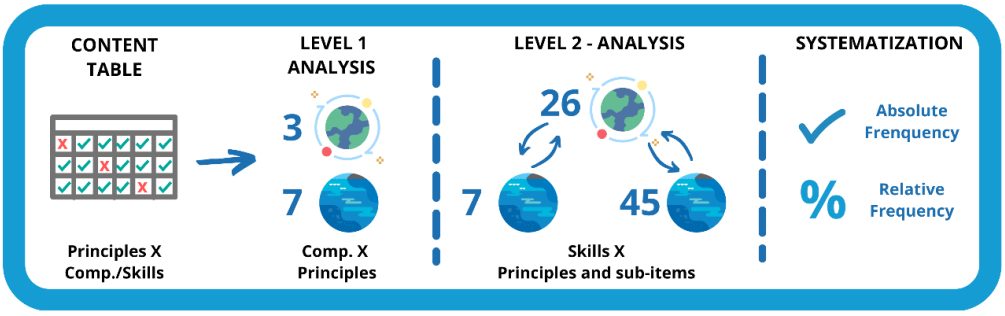
Based on this outline, possible relationships were proposed between the BNCC Specific Competences, and their respective Skills, with the Principles of Ocean Literacy and their respective sub-items. This proposition was operationalized by filling out a table with suggestions (in a illustrative and non-exhaustive way) of contents that potentially integrate these two references (BNCC and the Principles of Ocean Literacy). The con-

struction of the table was carried out in iterative steps. A detailed description of all stages of the table construction, as well as the complete table containing the suggested contents, can be accessed at Ghilardi-Lopes et al. (2023a - Portuguese version; 2023b - English version). For the present article, the table was simplified to demonstrate only the absence/presence of relationships.

Data analysis

The analysis of the relationships identified in the final table was carried out considering two levels of detail. In the first, we analyzed the relationship of each of the three Specific Competencies with each of the seven Principles of Ocean Literacy and their respective sub-items. This analysis provided an overview of the relationship between BNCC and Ocean Literacy. At the second level, we consider the relationship of each Skill, referring to each Specific Competence (N = 26), with each of the seven Ocean Literacy Principles and their respective sub-items (N = 45) and vice versa. The absolute and relative frequency (%) of relationships was quantified, based on the maximum possible number of relationships between Competencies or Skills with Principles and their sub-items (Figure 2).

Figure 2 – Methodological steps for quantifying the absolute and relative frequency of relationships between Specific Competences (Comp.) and Skills of the National Common Curricular Base (BNCC) for High School (EM) - area of Natural Sciences and its Technologies (CNT) and the Principles of Ocean Literacy and their sub-items



Source: The authors, 2023.

To simplify reading, we will abbreviate, throughout the text, Specific Competencies for SC (eg SC1 for Specific Competence 1); Principles and sub-items of Principles for P (eg P3a for Principle 3, sub-item a); and Skills for S (eg EM13CNT103 – which indicates High-School – 1st to 3rd grade, Natural Sciences and their Technologies, Specific Competence 1 and Skill 03 – was converted to S103). In the tables, the skills' codes will be maintained according to the BNCC standard. The detailed description of all the Skills and sub-items of the Principles can be consulted in Ghilardi-Lopes et al. (2023a -

Portuguese version; 2023b - English version).

Results

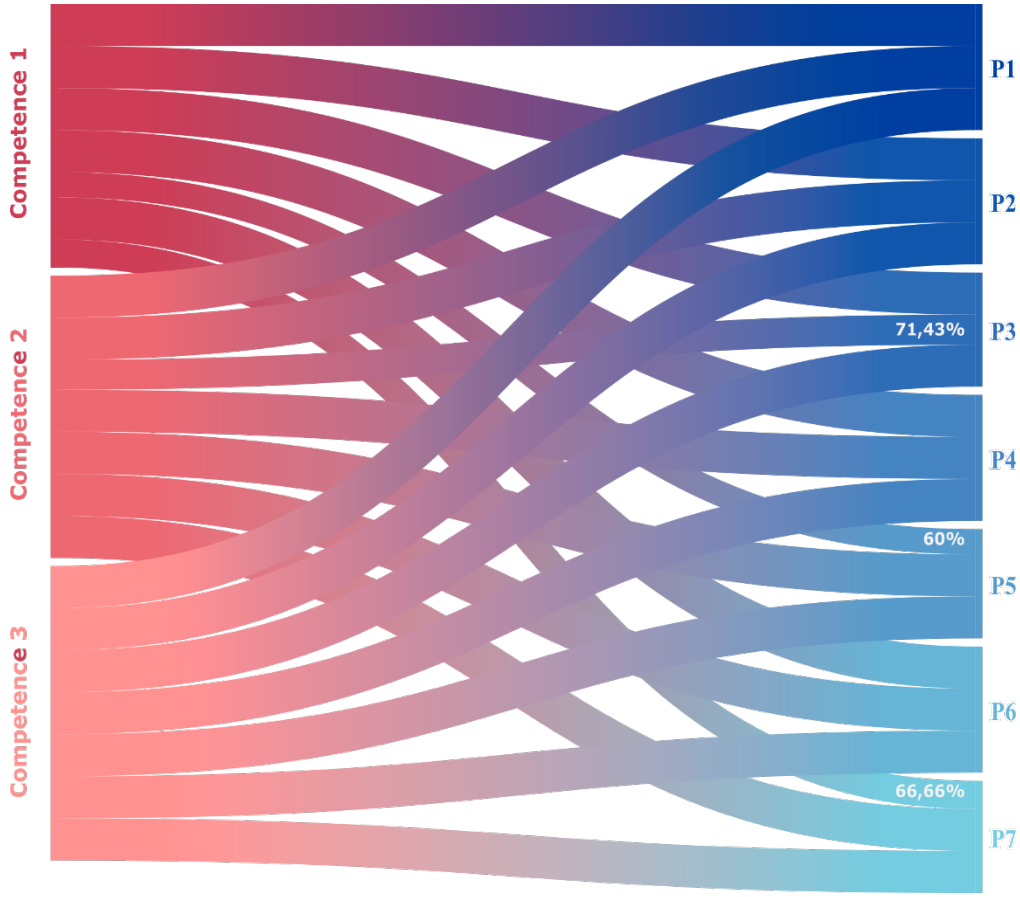
Specific Competencies in relation to the Principles and respective sub-items

Relationships with all Ocean Literacy Principles were identified for all SCs (Figure 3).

For SC1 (*Analyze natural phenomena and technological processes, based on the interactions and relationships between matter and energy, to propose individual and collective actions that improve production processes, minimize socio-environmental impacts and improve living conditions at the local, regional and global levels*), relationships were identified with 39 sub-items of the Principles out of a possible 45 (86.7%). For this SC, relationships were identified for 100% of the sub-items of P1, P2, P3, P4 and P6; 60% of the P5 sub-items (relations with P5c, P5e, P5f, P5i were not identified) and 66.66% of the P7 sub-items (relations with P7a and P7f were not identified).

For SC2 (*Analyze and use interpretations of the dynamics of Life, Earth and the Cosmos to elaborate arguments, make predictions about the functioning and evolution of living beings and the Universe, and support and defend ethical and responsible decisions*), relationships with 43 sub-items of Ocean Literacy Principles (95.5%) were identified. For this SC, only relationships with sub-items P3d and P3f were not identified, totaling 71.43% of identified relationships. As for SC3 (*Investigate problem situations and evaluate applications of scientific and technological knowledge and their implications in the world, using procedures and languages typical of the Natural Sciences, to propose solutions that consider local, regional and/or global demands, and communicate their findings and conclusions to different audiences, in different contexts and through different media and Digital Information and Communication Technologies - DICT*), relationships with all sub-items of the Principles were identified.

Figure 3 - Relationships found between the Specific Competencies of the Brazilian National Common Curricular Base and the Principles of Ocean Literacy and their respective sub-items. The thickness of the lines indicates the frequency (%) of sub-items for which relationships with Specific Competencies were identified. Frequencies less than 100% are indicated on the lines



Source: The authors, 2021.

Skills in relation to the Principles and respective sub-items and vice versa

Relationships were identified between each of the Skills of each SC with at least two Principles (Table 1).

For SC1, 100% of relationships with the Principles were identified for S101, S104, and S105. For S102, S103, and S106, the frequency of identified relationships was 71.4%. For S102, no relationships with P4 and P5 were identified and for S103 and S106, no

relationships with P2 and P4 were identified. Finally, for S107, no relationships were identified with P2, P4 and P5, totaling 57.14%.

For SC2, 100% of relationships with the Principles were identified for S201, S202, S203, and S206. For S204, no relationships were identified only with P3 and for S205 and S207, no relationships were identified only with P7. For S208, no relationships were identified with P3 and P4 (71.4%). The lowest frequency (28.6%) was for S209, for which relationships with P1, P2, P3, P6, and P7 were not identified.

For SC3, 100% of relationships with the Principles were identified for S301, S302, S303, and S306. For S304, S307, and S310, the frequency of identified relationships was 85.71% and these relationships were not identified only with P4. With a frequency of 71.4%, for S309, no relationships were identified with P2 and P4. For S305, with a frequency of 57.14%, no relationships were identified with P2, P4 and P5, and for S308, with a frequency of 42.8%, no relationships were identified with P2, P3, P4, and P6.

When we deepened the analysis for the sub-items of the Principles, relationships were identified between all Skills with at least three of these (maximum of 100% and average of 44% of relationships identified - Table 2).

The lowest number of relationships identified was for S209 (6.7%), with only P4b, P5e, and P5f. The highest number of relationships was identified for S303 (100% - Table 2).

If we consider the relationships identified from the point of view of the Principles in relation to the Skills, it can be observed that for no Principle we identified relationships with 100% of the Skills. For P1 and P7, the highest numbers of relationships with Skills (96.15%) were found. For P4, only 50% of relationships were identified (Table 1).

Finally, if we consider the relationships identified for each of the sub-items of Principles in relation to Skills, sub-item P3d was the one for which the lowest number of relationships was identified (15.4%) and for sub-item P6e the highest number of relationships was identified (73.1%) (Table 2).

Table 1 – Relationships identified between the Skills of each Specific Competence of the Brazilian National Common Curricular Base (Natural Sciences - High School) and the Principles of Ocean Literacy. Cells filled in green mean identification, by the authors, of a relationship, whereas cells without filling mean no identification of a relationship. The frequencies (%) of the identified relationships are indicated.

			PRINCIPLES							Freq.
		SKILL	P1	P2	P3	P4	P5	P6	P7	%
SPECIFIC COMPETENCE	SC1	EM13CNT101								100,0
		EM13CNT102								71,4
		EM13CNT103								71,4
		EM13CNT104								100,0
		EM13CNT105								100,0
		EM13CNT106								71,4
		EM13CNT107								57,1
	SC2	EM13CNT201								100,0
		EM13CNT202								100,0
		EM13CNT203								100,0
		EM13CNT204								85,7
		EM13CNT205								85,7
		EM13CNT206								100,0
		EM13CNT207								85,7
		EM13CNT208								71,4
		EM13CNT209								28,6
	SC3	EM13CNT301								100,0
		EM13CNT302								100,0
		EM13CNT303								100,0
		EM13CNT304								85,7
		EM13CNT305								57,1
		EM13CNT306								100,0
		EM13CNT307								85,7
		EM13CNT308								42,8
		EM13CNT309								71,4
		EM13CNT310								85,7
Frequency		%	96,2	73,1	84,6	50,0	88,0	92,3	96,2	83,0 82,9

Source: The authors, 2021.

Table 2 – Relationships identified (filled cells) between the Specific Competences (SC) and Skills of the Brazilian National Common Curriculum Base (Natural Sciences - High School) and the sub-items (Sub.) of the Principles (P) of Ocean Literacy. The frequencies (Freq. - %) of the identified relationships are indicated

		PRINCÍPLES																																											
		P1								P2					P3							P4		P5										P6							P7						Freq.
	Hab./Sub.	A	B	C	D	E	F	G	H	A	B	C	D	E	A	B	C	D	E	F	G	A	B	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	A	B	C	D	E	F	%
SPECIFIC COMPETENCE SC1	EM13CNT101																																														57,8
SC1	EM13CNT102																																														28,9
SC1	EM13CNT103																																														15,6
SC1	EM13CNT104																																														26,7
SC1	EM13CNT105																																														46,7
SC1	EM13CNT106																																														26,7
SC1	EM13CNT107																																														15,6
SC2	EM13CNT201																																														53,3
SC2	EM13CNT202																																														71,1
SC2	EM13CNT203																																														75,6
SC2	EM13CNT204																																														26,7
SC2	EM13CNT205																																														37,8
SC2	EM13CNT206																																														80,0
SC2	EM13CNT207																																														37,8
SC2	EM13CNT208																																														22,2
SC2	EM13CNT209																																														6,7
SC3	EM13CNT301																																														86,7
SC3	EM13CNT302																																														95,6
SC3	EM13CNT303																																														100,0
SC3	EM13CNT304																																														55,6
SC3	EM13CNT305																																														20,0
SC3	EM13CNT306																																														51,1
SC3	EM13CNT307																																														17,8
SC3	EM13CNT308																																														8,9
SC3	EM13CNT309																																														42,2
SC3	EM13CNT310																																														37,8
Freq.	%	69,2	30,8	46,2	61,5	53,8	69,2	57,7	53,8	42,3	30,8	46,2	50,0	23,1	65,4	42,3	26,9	15,4	46,2	26,9	38,5	42,3	26,9	30,8	46,2	34,6	34,6	30,8	34,6	50,0	42,3	30,8	42,3	38,5	69,2	42,3	57,7	73,1	38,5	53,8	30,8	26,9	65,4	65,4	34,6	38,5	44,0 43.9

Source: The authors, 2021.

Discussion

The results of the present study indicate that there is content related to the ocean that can be utilized in schools to cover all the fundamental natural science Specific Competencies (SC) and skills as outlined by the BNCC for high school students. However, it is important to note that this analysis was meant to be illustrative rather than exhaustive. Therefore, if others were to carry out the same exercise, it is possible that even more relationships could be identified since the authors of the present study have expertise in biological and oceanographic sciences, which may have influenced the number of relationships that were identified and agreed upon, as well as any gaps that exist. For example, we can mention the skills S209 (Analyze stellar evolution by *associating it with models of origin and distribution of chemical elements in the Universe, understanding their relationships with the necessary conditions for the emergence of solar and planetary systems, their structures and compositions and the possibilities existence of life, using representations and simulations, with or without the use of digital devices and applications*) and S308 (*Investigate and analyze the operation of electrical and/or electronic equipment and automation systems to understand contemporary technologies and assess their social, cultural and environmental impacts*), for which few relationships were proposed, which could probably be improved with the contribution of someone with an astronomy or engineering background.

Additionally, some characteristics of both the SC and the Principles favored, in our view, the identification of relationships that demonstrate the role of the Ocean as an integrating theme in school curricula. We are going to discuss this role here considering aspects related to interdisciplinarity, complexity, the relationship with scientific work, and the relationship with the social dimension.

Interdisciplinarity

Interdisciplinary practices in the school setting aim to integrate scientific knowledge and apply it in a manner that addresses everyday questions, thereby promoting citizenship education (FAZENDA, 2015; LENOIR; HASNI, 2016).

Ocean Literacy's P7 emphasizes the interdisciplinary nature of ocean science, specifically sub-item P7f, which explicitly highlights the requirement of interdisciplinarity for comprehending oceanic processes and underscores the need for collaboration among all scientific fields, including the social sciences. According to Claudet et al. (2020), greater integration between different science disciplines and an improvement in educational processes that promote Ocean Literacy are some of the fundamental strategies for achieving planetary sustainability. As an example, we can mention the phenomenon of climate change, whose understanding requires interdisciplinary knowledge, especially of the relationship between the ocean and the carbon cycle, but also of the social processes related to such changes. (EISENACK, 2013).

It was also possible to notice that SCs have several Skills that demand an interdisciplinary perspective. SC1 (*Analyze natural phenomena and technological processes, based on the interactions and relationships between matter and energy, to propose individual and col-*

lective actions that improve production processes, minimize socio-environmental impacts, and improve living conditions at the local, regional, and global level), for example, presents Skills that demand knowledge of structuring concepts for the Natural Sciences (matter and energy), which are strongly linked to the disciplines of physics and chemistry, as well as the connections between them. This connection can be evidenced, for example, in contents related to the dynamics of the hydrological cycle, evidenced in P1, especially in sub-item P1f (*The Ocean is an integral part of the hydrological cycle, being connected to all water reservoirs on the planet through the process of evaporation and precipitation*), for which relationships with all seven SC1 Skills were identified.

In contrast, SC2 encompasses a range of skills that pertain to the development of biological, physical, chemical, and geological systems, making it easier to establish connections with the Principles, particularly P6, which deals with the interaction between the Ocean and humanity. Subitems P6c, P6d, and P6e, which underscore the substantial human presence and impact on coastal areas (BARRADAS et al., 2021), enable the identification of such relationships as human activities in these regions have significant potential to affect the dynamics of marine and coastal systems.

Finally, SC3 encompasses a range of skills related to language and communication. Certain sub-items of the Principles permit discussions that are directly relevant to the sustainability of human life on the planet, such as P3g (*changes in Ocean circulation have produced considerable and abrupt changes in climate throughout Earth's history*); P6b (*from the Ocean we get food, medicine and living and non-living resources...*); P7c (*over the last 50 years, the exploitation of marine resources has increased significantly...*); and P7d (*new technologies, sensors and tools enhance our ability to explore the Ocean*). These sub-items facilitate the use of didactic strategies that require strong communication skills and may involve various forms of language.

The development of complex thinking

The need for interdisciplinarity, in large part, is evident because research problems related to ocean systems are complex and have multiple dimensions (PINHO; TURRA; ANDRADE, 2021), demanding the development of a systemic thinking (BRENNAN; ASHLEY; MOLLOY, 2019) in the school environment. The physical, chemical, and geological dimensions are mainly evidenced in P1, P2, and P3; the biological and ecological dimensions, mainly in P4 and P5; the social and economic dimensions, mainly in P6 and the scientific and educational dimension, mainly in P7.

A system-thinking student can understand that the loss of a marine species or an impact on it can unbalance the entire food chains in the marine environment, disrupt the functioning of that ecosystem and even impact the climate of the planet. Similarly, alterations to the planet's climate may be linked to the loss of marine biodiversity and pose a threat to the economy and the overall planetary health (TURRA; MAIA, 2015). This knowledge can be stimulated from contents that express the relationship between S202 (*Analyze the different forms of manifestation of life, the favorable environmental condi-*

tions and the limiting factors to them...) and P3, P4, and P5.

Another example is the realization that waste products such as sewage or garbage generated in urban areas, even those located far from the coast, can impact the quality of coastal waters and thereby affect the marine biota and its use by various human populations. In such cases, it is beneficial to utilize contents that highlight the relationship between S203 (*Assess and predict the effects of interventions in ecosystems and the impacts on living beings based on life maintenance mechanisms, in the cycles of matter and in the transformations and transfers of energy ...*) and P1, P3, P5, P6, and P7 or those that express the relationship between S206, which involves discussing the importance of preserving and conserving biodiversity and evaluating the effects of human actions and environmental policies to ensure the sustainability of the planet, and P6 and P7.

Understanding complexity enables students to establish connections (MORIN, 1992; SANTOS; HAMMERSCHMIDT, 2012) between the different dimensions of oceanic knowledge. In order to facilitate a systemic way of thinking among young people, it is imperative that the teaching staff is adequately prepared, valued in their workspace (OLIVEIRA; PIRES, 2014), and has the necessary conditions (such as time and infrastructure) to propose activities that contribute to this objective in the school environment. Thus, we consider it crucial to invest in teacher training (NÓVOA, 2019) and value learning methodologies that promote the formation of critical students, who are open to dialogue, proactive in constructing their knowledge and creativity (FRANKIV; DOMINGUES, 2016). In doing so, we can transform current patterns of ecosystem goods and services utilization and the equitable distribution of their benefits towards more sustainable, fair, and cooperative approaches (GHILARDI-LOPES; BERCHEZ, 2013; WORM et al., 2021), while also increasing the interest of young people in scientific careers and engagement in ocean policy issues (WULFF; JOHANNESSON, 2019).

The Scientific Doing

Some Skills, especially those of SC3, emphasized content related to the procedures and languages of the Natural Sciences, such as raising hypotheses, testing and controlling variables and the use of logical reasoning (S301), as well as communication and understanding scientific information (S302 and S303). When we relate these Skills to the Principles, we recognize a series of contents that can favor the understanding that the Ocean is a place for investigation, as it is wide and diverse (P1), as it is the stage for problems arising from human activities (P6), as well as by knowledge gaps and scientific research possibilities (P7). According to Greely (2008, p. 10), "*sustaining a healthy and vibrant lifestyle on planet Earth requires a citizenry with a broad understanding of key ocean science concepts and the ability to critically engage with cultural and moral decisions that involve scientific knowledge of the ocean.*" We emphasize here that scientific education is fundamental not only for the formation of citizens capable of asking questions and investigating everyday issues involving scientific knowledge about the Ocean, but also of citizens who can and should act in decision-making related to the Ocean. It was not the objective of the present study to explore didactic strategies for the promotion of scientific education

related to the Ocean in schools, which can find in the exercise carried out here a broad base of examples and opportunities.

The social importance of the ocean

Some of the Skills related to both SC2 (ex. S206 - *Discuss the importance of preserving and conserving biodiversity, considering qualitative and quantitative parameters, and assessing the effects of human action and environmental policies to guarantee the sustainability of the planet*), as well as the SC3 (S301 - *Construct questions, elaborate hypotheses, predictions and estimates, use measuring instruments and represent and interpret explanatory models, data and/or experimental results to construct, evaluate and justify conclusions when facing problem situations from a scientific perspective*; S302 - *Communicate, to different audiences, in different contexts, results of analysis, research and/or experiments, preparing and/or interpreting texts, graphs, tables, symbols, codes, classification systems and equations, through different languages, media, digital information and communication technologies, in order to participate and/or promote debates around and scientific and/or technological topics of socio-cultural and environmental relevance*; and S303 - *Communicate, to different audiences, in different contexts, results of analysis, research and/or experiments, preparing and/or interpreting texts, graphs, tables, symbols, codes, classification systems and equations, through different languages, media, digital information and communication technologies, in order to participate and/or promote debates around scientific and/or technological themes of sociocultural and environmental relevance*) involve social aspects of science, such as social participation and human values associated with the Ocean (CAPRETZ, R.; MADALOSSO, 2021). Such values can also be worked on at school based on content related to SC2 and SC3. It is possible to create space for discussions about the existing connection between all living beings on the planet, about how human survival is strongly linked to the health of the Ocean, to reflect on what is the Ocean that we leave for future generations and how beautiful and inspiring they are ocean landscapes. These values are present in all Ocean Literacy Principles, but especially in P6 (*The Ocean and humanity are strongly interconnected*) and P7 (*There is much to discover and explore in the Ocean*). School activities can stimulate important social skills for students' citizenship education (DEL FAVERO; ANDRADE, 2021; LENOIR; HASNI, 2016), for example: (1) reflection and discussion on the environmental policies in force in the country and which of them are related to the Ocean (S206 and P6), (2) the debate on the strategies that should be considered, with a scientific basis, to face problem situations related to the Ocean and planetary sustainability (S301 and P6 and P7), (3) reflection on the reliability of information about the Ocean that reaches the general public from different sources (e,g, podcasts and social media BARATA, 2021) and how to combat fake news (S302 and P7); (4) the search, manipulation, analysis and communication of information derived from ocean research (S303 and P7) or, still (5) the importance of valuing different forms of knowledge about the Ocean, such as traditional knowledge and practices (S206 and P6, S302 and P6; S304 and P7; S305 and P6 and P7), which can bring the Ocean Literacy movement closer to the reality of the school community in coastal territories (BLACKMORE, 2007; WORM et al., 2021).

Final thoughts and recommendations

In the current study, we have identified contents that demonstrate the relationships between the Skills and Specific Competencies in the area of Natural Sciences for High School outlined in the BNCC and the Principles of Ocean Literacy, despite any conceptual or pedagogical weaknesses that may exist in either document. Schools across Brazil have the opportunity to incorporate actions and propose Ocean-related content in their curricula, thereby contributing to citizenship education on a topic that is crucial for the continued existence of our species on this planet. More than that, this study demonstrates that incorporating the Ocean theme in pedagogical practices is in line with the BNCC and can be carried out by educators, provided that they receive encouragement (such as support from the pedagogical team, infrastructure, recognition of teaching work, training opportunities, availability of didactic and paradidactic materials). It is worth noting that the exercise carried out in this study has limitations related to the background of the authors, and it is possible that other relationships may be identified by individuals with different backgrounds or perspectives. However, this study concluded that using the Ocean as an integrative theme in the Natural Sciences area has potential, and this potential could be even greater when considering other areas. Therefore, we recommend conducting a similar exercise for the other areas covered in basic education.

Finally, the results presented here do not refer to how to ensure that these contents are taught in a way that we recognize the importance of teacher training processes so that these contents are inserted in the pedagogical proposals and teaching plans of schools, as already emphasized in several publications on Ocean Literacy (ex. GUEST; LOTZE; WALLACE, 2015; INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION, 2021) and interdisciplinary teaching practices (FAZENDA, 2015). Therefore, just like Principle 1 of Ocean Literacy, in which it is found that the "Earth has a global ocean" that interconnects its different regions, the Ocean has this same role in school curricula, interconnecting and re-signifying the contents in the sense of fostering the Specific Competencies in the formation of critical citizens committed to the future of the planet and humanity.

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AMBIENTE & SOCIEDADE 25 anos 25 años 25 years

SciELO

Oceano como tema interdisciplinar na educação básica brasileira

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Resumo: Há grande desconhecimento da ciência sobre o Oceano e uma desconexão entre conhecimento científico e entendimento público sobre este ambiente. Considerando a importância da Letramento Oceano na sociedade, ilustramos nesse estudo como a complexidade e a transversalidade do Oceano possibilita diálogos e reflexões disciplinares e interdisciplinares nas escolas. Baseado em uma análise documental, o presente trabalho identificou a presença e frequência de relações entre as Competências Específicas (CE) da Base Nacional Comum Curricular (BNCC - Ensino Médio) e os Princípios da Letramento Oceano, com base em conteúdos das Ciências da Natureza. Houve identificação de relações entre todos os Princípios e todas as CE, favorecida por aspectos como interdisciplinaridade, fazer científico, dimensão social e complexidade. Considerando o caráter ilustrativo do presente trabalho, compreendemos a potencialidade do uso do Oceano como tema integrador e a necessidade de processos formativos de educadores e de planejamento de propostas pedagógicas escolares abrangendo o tema.

***Palavras-chave*:** Ensino de ciências; educação para a sustentabilidade; formação para a cidadania; pensamento sistêmico; ODS 14.

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Resumen: Existe una falta de conocimiento científico sobre el océano y una desconexión entre el conocimiento científico y la comprensión pública de este entorno. Considerando la importancia de la Cultura Oceánica en la sociedad, ilustramos en este estudio cómo la complejidad y transversalidad del Océano posibilita diálogos y reflexiones disciplinarias e interdisciplinarias en las escuelas. A partir de un análisis documental, este trabajo identificó la presencia y frecuencia de relaciones entre las Competencias Específicas (CE) del Currículo Base Común Nacional y los Principios de la Cultura Oceánica, a partir de contenidos de las Ciencias Naturales. Se identificaron relaciones entre todos los Principios y todos los CE, favorecidas por aspectos como la interdisciplinariedad, el trabajo científico, la dimensión social y la complejidad. Entendemos el potencial de utilizar el Océano como tema integrador y la necesidad de procesos educativos para los educadores y para la planificación de propuestas pedagógicas escolares sobre el tema.

Palabras-clave: Enseñanza de las ciencias; educación para la sostenibilidad; formación para la ciudadanía; pensamiento sistémico; ODS 14.