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Aesthetic surprises and considerations when researching marine science education with art

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Introduction: Why was the study undertaken? What was the research question, the tested hypothesis or the purpose of the research? The research question is: What are the implications of disciplinary aesthetics when marine science meets art in educational research? Children in schools from Victoria, Australia were engaged in a series of marine science fieldtrips, workshops and lessons based on the Great Southern Reef, a temperate marine environment of Australia. They created drawings based on provocations, to depict their knowledge of marine species, before and after these education experiences.

Methods: When, where, and how was the study done? What materials were used or who was included in the study groups (patients, etc.)? This paper shares the mixed methodology used by focusing on the qualitative methods used, that arose out of a need to understand the role of aesthetics in this research project. This paper documents the analysis of data that included children's drawings and dialogue between researchers and children from interviews. We discuss insights into the role of aesthetics that were revealed in the visual and narrative data from perspectives of children's learning and how the researchers were able to understand this. These findings are discussed considering the teaching intentions and procedures used, the importance of this multimodal approach to research that revealed aesthetics of science, visual art and language in education.

Results: What answer was found to the research question; what did the study find? Was the tested hypothesis true? The research reveals the important role drawing has when trying to understand the students' varying degrees of understanding marine science education. Variables include: their prior experience with marine environments, students' drawing abilities, stylistic elements (that can render an image 'confident' or 'sketchy'), compositional devices and use of perspective that their drawings depict (looking at a pier from underwater or through snorkel goggles). It also includes interpretations and explanations of their drawings and other uses of language such as the use of written labels to reinforce or clarify parts of their drawings.

Discussion: What might the answer imply and why does it matter? How does it fit in with what other researchers have found? What are the perspectives for future research? This research reveals the important role of multi-modal approaches in science learning and the significant and dependent role of visual art and words, for students to communicate their learnt content knowledge. It highlights the aesthetic experiences that must be taken into consideration when teaching, learning and when understanding what has been learnt.

KEYWORDS

aesthetics, art, marine science, teaching, learning, methods, Australia, Great Southern Reef

Introduction

This study forms part of a marine science education programme that was developed for primary schools by a team of marine scientists and researchers, in southern Victoria, Australia. The aim of this programme was to increase teachers' and students' awareness and understanding of their local marine environment, the Great Southern Reef (GSR). The GSR remains unfamiliar to most people and receives less media attention and grant funding, compared to tropical reef systems such as the Great Barrier Reef (Bennett et al., 2016). The GSR is a temperate rocky reef system made up of dense kelp forests that are interconnected along 8,000 km of Australia's southern coast (Bennett et al., 2016). The GSR is characterised by its high species richness and endemism and plays a significant role in Australia's economy, culture, and environment. Thus, it is vital for the Australian community, including children, to develop an understanding for and build valuable connections to the GSR.

To evaluate the students' understanding of the GSR, drawings and focus group interviews were conducted before and after the marine education programme. Here, we describe how both quantitative and qualitative methods were used to analyse students' understanding of their local marine environment and report on the qualitative method to evaluate the aesthetic experiences expressed through art and narrative dialogue. The qualitative method outlined highlights the importance of both qualitative and quantitative analyses to evaluate the students' science understanding in the context of this local marine environment. We share our methodology and methods by presenting examples of our analysis from one of the participating classes and examples from three student experiences.

Connections of place, aesthetics, and interestedness

One of the unique benefits of the marine education programme was the proximity of the school to the local marine environment. Place-based environmental education is one way to engage children as it enables them to explore their own local environment that they are somewhat familiar with and therefore be able to make connections between what is being studied and their own lives (Lai, 2021; Wright et al., 2022). In this sense, the marine education programme aligns with Dewey's (1958) theory of the interconnection of nature and experience, as the students were immersed in their environment and engaged in a continuity of communicating and learning about the marine aspects of their environment.

Whether or not participants are interested or have a 'taste' for the topic being studied is a well-documented feature of research in aesthetics for teaching and learning (Wickman, 2005, 2017; Silvia, 2012; Anderhag, 2017; Hannigan et al., 2021). Wickman (2017, p.32) explains a persons' process of learning as a 'simultaneous transformation' of a person 'as a whole', which is 'a transformation of taste'. He writes:

> Both Dewey (1913) and Bourdieu (1984) have employed the notion of taste to emphasise the continuity of all three faculties for learning as the transformation of habits (habitus of Bourdieu) of making certain distinctions (cognitively, normatively, and aesthetically) about what objects, events and actions should be included and excluded.

This quote is applicable to the aim of the marine education programme where students participated in immersive, place-based experiences relating to their local marine environment where there was opportunity to develop a 'transformation of taste'. Encouraging children to learn about the GSR contributes to Australia's push to create an ocean literate society (Freitas et al., 2022). The GSR is facing rapid climate change impacts and urban development pressures (Bennett et al., 2016). Recent data indicates there is a high risk of extinction of endemic reef species in southern Australia (Edgar et al., 2023). Raising awareness of the GSR and the threats it is facing is imperative to help children understand and appreciate their local marine environment and to foster ocean stewardship (Freitas et al., 2022). In addition, knowing their local natural environment has been shown to influence young people's imagined spatial futures and ongoing education interests (Rönnlund, 2020). Through the place-based opportunities and classroom activities offered in the marine education programme, we seek to analyse the students' interconnection with their marine environment, through aesthetic evaluation developed in the qualitative approach of our mixed methods research.

The significance of art in the research methods

Diagrammatic representations are used as learning strategies in science education to improve or help students engage in classes and learning process (a multi-modal way of learning), to represent science (this might involve art tuition on learning to draw science systems or specimens) and communicate or reason (Ainsworth et al., 2011). Drawing and other arts are used to recall or demonstrate learning in performed or visual ways. For example, in an art and environmental science project, puppets were created to depict students' understandings of endangered species then performed in small portable theatres to communicate animal extinction (Hannigan et al., 2021; Hannigan and Ferguson, 2022). Drawings have been introduced for school students to represent science and scientists (Finson, 2002), their science learning (Tytler et al., 2013; Flowers et al., 2015; Roseler and Dentzau, 2017) and specific models of science experiments (Neumann and Hopf, 2017). Drawings have also been used to explore primary school children's mental models of marine environments (Atasoy et al., 2020) and to assess their learning over time (Cainey et al., 2012).

This marine education programme was focused on the science curriculum rather than the art education curriculum. As is common in science education, propositional knowledge (species, environment, etc.) was taught with justifications of this knowledge being assisted in experiential ways of teaching and learning such as: teachers and researchers facilitating students to experience their local environment on field trips, using illustrated swap cards and being taught by locally-based marine scientists. Brock and Hay (2019) explain the value of experiential engagement to acquire knowledge, arguing that 'non-propositional knowledge is a significant component of scientific experience' (p.995). The inclusion of non-propositional knowledge, experiential learning, arts epistemology and propositional knowledge were important pedagogical considerations in this study.

At the heart of the study was the notion of change, as children would be learning (which is change) but also, in this climate change environment scientists are constantly discovering new insights so knowledge is not static. It could be said that climate change influences education about: species, their habitat, their numbers and even in some cases their colours (as their colouring changes to adapt to heat or loss of their habitat). The very nature of creating art is that things change (being creative artistic processes). Therefore, art epistemology was useful to help understand and map these changes in students' learning.

Before and after the programme, children were provided with coloured chalk-pastels, to show their learnings about what their local marine environment looked like and the marine species within it. Drawing on Reiser's (1950) discussion of a philosophy of symbolism or semiotics to art, we construct a model of the three phases the students engaged in as part of art epistemology in their learning process. The model is based on the letters H, I and E (which do not stand for any particular words):

(H) The student as artist and the subject matter learnt about the GSR (fish, kelp, environment etc).
(I) 'The cluster of signs (propositions, ideas with a feeling tone, etc.) which arise in the mind of the (artist) as a result of looking (and learning about H) (i.e., images, ideas)' (Reiser, 1950, p.696).
(J) (E) the drawing created as a result of these processes.

The children's drawings are not mere copies of (H) or imitations of reality. They have been processed through the opportunity in (I)–to respond to the prompt by the teachers to 'draw a picture of what you would expect to find if you were snorkelling on your local beach' to use the materials provided (crayons, paper), given time and a degree of artistic freedom to do this task. '(E) proceeds genetically from (I) and (I) is complex and includes all the propositions of the artist about H' (Reiser, 1950, p.699). Another way of framing it is that 'It may be sometimes true that the psychological intention of the artists is to make our of (E) a duplicate of (H), but what he does it not true to (H), but true to (I), that is, to what he thinks about (H)' (p.699). Theories of materiality in the creative process would add that the engagement with and consideration of the materials available have an impact on this whole process as well.

Throughout this process of (H), (I) to (E), children have been learning first about science in connection to the subject matter of (H) including propositional knowledge. We capture their learning through their drawings and through interviews with them about all three phases of this process.

Brooks (2017) highlights how young peoples' visual representations through drawing are connected to their thinking skills rather than verbal language skills and abilities. This means if language skills aren't fully developed, words (for marine species in this example) aren't known, or children have other languages, then art can also be a powerful way to communicate knowledge, feelings and ideas.

Choi and Pak (2006) define interdisciplinary education as interactive because it 'analyzes, synthesises and harmonises links between disciplines into a coordinated and coherent whole' (p. 351). Interdisciplinary education was achieved through generating new science knowledge using artistic epistemology approaches under the banner of a marine education programme. In addition, this research was multi-modal as it invited students to learn and explore the topic through children's story books, identification cards, field trips, conventional classroom teaching and learning as well as drawing their learning and discussing both drawings and learning with the researchers.

Using art in education can encourage knowledge to 'emerge through the multiple ways in which we engage with and in our world: movement, touch, emotions, intuition and making' (Shields et al., 2016, p.46). However, understanding artworks requires conversation and checking in with the creator—we cannot assume our own. This was considered and addressed with the inclusion of the qualitative methodology of arts-based and narrative inquiry and methods of cross referencing our analysis and understandings of each drawing's content/subject matter, employing a hermeneutic approach and bracketing out our own assumptions by sharing these with each other, to understand the relationship between (H), (I) and (E) above.

The design of the research, the methods, the particular prompt (which was quite open) for children to draw their learning, and the opportunities provided to share their place and environment as part of this learning, were the key elements of the project. Place was also an important consideration and art has been well documented to help engage students to understand their environment and themselves within it (California Department of Education, 2019). The many place and identity references in artists' work and arts-led research (see Casey, 2005; Jokela, 2008; Byrne et al., 2010; Dear, 2011a,b) and their claims of the interconnection of place and identity and the role of the creative process in this, suggest art is about making sense of place and self in some form. It is after all through art that artists (and students engaged in making art) make sense of their world and themselves within it (Heidegger, 1969; Malpas, 2018). As Sullivan (2005) notes, there is an 'emphasis on identity construction in the visual arts, as artists in particular search for self and place' (p. 172).

Aesthetic considerations in assessing, interpreting, and analysing art

Dewey (1934) critiques the notion of High Art or Museum Art, because these notions of art, tend to be separated from 'ordinary everyday modes of experience and activity'. Dewey promoted a more natural or ecological notion of aesthetics, which fits into this project given it explores an eco-marine environment and involves children, their art and use of words. He believed that being able to express rhythms from our ecology or interconnection with our environment, through the forms of art (line, shape, tone, balance etc.) is how artistic form emerges. Dewey (1934) writes, 'Underneath the rhythm of every art and of every work of art there lies, as a substratum in the depths of the subconsciousness, the basic pattern of the relations of the live creature to his environment' (p. 150). This is a consideration for the aesthetic analysis and discussion of this paper given we used art and words (conversation and labels on drawings) with a focus on environmental science learning.

As above, children's art is not being judged as 'high' or 'museum quality' art. Seeley (2015) also highlights different categories of 'art' suggesting there are 'anti-aesthetic conceptual artworks, works designed primarily as objects of aesthetic contemplation, and everything in between' (p.39). These different kinds of art suggest we should re-think the way we interpret, respond or make sense of an

artwork given that some art is not even 'intentionally designed to produce aesthetic experiences in consumers' (Seeley 2015, p.39). This point and Dewey's critique above about being open to individual's experiential ways of creating and understanding art, such as rhythms from our ecology became paramount in this project.

Children's depictions of their learning through their own style of drawing meant we needed to be aware of different categories of art that might influence us. We needed to be careful about how we, as researchers, responded to the children's artworks and how our responses might inform our interpretations and potential misunderstandings of their drawing content (e.g., correct or in-correct species). That is, we might be seduced by the brilliance of a drawing's style, when in fact the intention of the child-artist was to depict maximum correct species following the lessons and prompts they were given. We need to not go looking for 'great works of art' but instead understand the art and words in context to the educational and research programme.

The researchers aimed to seek evidence through the students' drawings of the ideas embedded in the marine education programme, with a particular focus on the local marine environment and species found there. Assessing the content of young students' art to check if they have included correct animal species, or plants relative to the environment they are studying, is fraught due to the cultural and world views of students which might influence their choice of colour and the way they choose to depict an environment (e.g., the sea from a boat, from a pier, from underwater, through snorkel goggles etc.) depending on their own experiences. Additionally, those viewing or assessing the art might be influenced by ideas of what constitute successful art or they might find that they have a preference for a particular genre, style or aesthetic preference. Some assessors might inadvertently allow such preferences to influence their opinions or assessments of children's art. For example, even if researchers or assessors are looking for evidence of 'correct marine species' in children's drawings, they might also inadvertently start judging how well these species were drawn (and perhaps miss some if they were not easily recognisable), or judge how well they are composed with other elements of the drawing (colour, lines, shape, shading)—therefore making more sense aesthetically to the assessor.

Another consideration for assessing children's learning based on their drawings, is that some might value art and art education practices that are more about students developing their art over time, where the creative processes is more important than the end result. Art that is more about the creative process than the end result is quite common in contemporary art practices and art education. Part of its preference in art education is Deweyan in that it is based on 'a desire to democratise artmaking within communities rather than within elite groups and to evaluate the impact of process rather than to prioritise aesthetic judgements about products' (Hyland-Russell and Groen, 2013, p.59). Such art or creative processes can potentially impact the researcher/assessor's interpretations or judgements when observing students creating art, or at the interview stage when students explain their work. An example of this is if a child was explaining that they had not quite finished the drawing, or what they were hoping to do next in the drawing.

These are all considerations that came into play as we considered the methods and engaged in the methodological considerations when conducting this research.

Methods

Methodological considerations

As has already been mentioned, this paper documents a research project that involved a marine education programme study to enhance ocean literacy in the primary/elementary classroom by promoting a greater understanding of the Great Southern Reef (GSR). The methodology and methods of this research were based on the effectiveness of this marine education programme on the students understanding about the GSR.

Initially, the method of analysis was focused on quantitative evaluation, however, it soon became important that qualitative analysis was required, given the aesthetic nature of the drawings and the researchers' awareness that some of the drawings were open to interpretation. Therefore, we complimented the quantitative method with a qualitative analysis; making it a narrative and arts-based inquiry. This became a mixed methodology (Creswell and Creswell, 2003). We describe both methods in more detail in the research programme and analysis section below.

This paper documents the qualitative aspect of our mixed methodology to highlight how and why the aesthetic evaluation became a valuable complement to quantitative analysis for evaluating science understanding.

Our mixed methodological approach incorporates constructivist/interpretivist worldviews as children make sense of their marine environment through learning at school and during school excursions, as well as their own place-based and lived experience living in local seaside towns. Our methods considered this worldview by providing opportunity for students to incorporate their own experiences in their accounts of learning (through their own perspectives and stylistic approaches to drawing, and open question interviews where they could explain these).

Qualitative research is non-linear and complex (Stake, 2010). It was important for the researchers to provide opportunity for students to express their perspectives and learning and explain them in the interviews. As Josselson (2011) reminds us,

> Narrative inquiry approaches recognise that narrators are constructing ordered accounts from the chaos of internal experience and that these accounts will likely be multivocal and dialogical in that aspects of self will appear in conversation with or juxtaposed against other aspects. There is never a single representation (p. 226).

It was important for the researchers to triangulate their interpretations and understandings of the data through the mixed methods used. Techniques to do this include making individual notes about interpretations and observations of participant data during the analysis phases. These help researchers to be more conscious of individual interpretive thinking. By sharing these with each other there is the potential to open up discussions about how each researcher is making sense of the data and therefore how the researchers can arrive at understandings as a team. By writing down individual thoughts, observations and assumptions, these become more concrete and are able to be reflected upon or shared then bracketed out (Moustakas, 1994) so they do not subconsciously influence researcher interpretations and analysis.

This process of checking in with one anothers' interpretations is called engaging in a hermeneutic circle. People engage in a hermeneutic

circle because of their need to find out why people behave and the significance with which people interpret their own actions (Geertz, 1971). Davidson's (2006) explains the usefulness of learning of peoples reasons, which can then help explain why they might have acted (or drew a drawing) in a particular way. He highlights the importance of setting up the right investigation to help understand and interpret a person's actions and accounts of experience. However, in addition to setting up the right investigation, the hermeneutic interpreter and researcher will need to challenge their own focus on their own issues, as Gadamer (2004).

explains:

> A person who is trying to understand a text is always projecting (they) projects a meaning for the text as a whole as soon as some initial meaning emerges in the text. Again, the initial meaning emerges only because (they) is reading the text with particular expectations in regard to a certain meaning. Working out this fore-projection, which is constantly revised in terms of what emerges as (they) penetrates into the meaning, is understanding what is there (p. 267).

Interpreting and developing meaning from the point of view of each participant is fundamental to understanding each participant's experiences, interpretations, and understandings. For this reason, the hermeneutic approach to researching place and identity is compatible, useful, and necessary to understanding and learning new knowledge. We felt this complimented the quantitative methods as a solid inquiry into the children's learning; as Palinkas et al. (2011) point out, mixed methods are more successful to reveal research issues, than qualitative or quantitative methodologies on their own.

The research programme

Teachers involved in the marine education programme participated in a 3-day workshop (approximately 25-h contact) with the researchers prior to conducting ocean-themed activities in their classroom. The research team supported the teachers and school by providing a teachers' guide (freely downloadable at: www.pruefrancis.com/science-3-4/) along with a sample of 6 nonfiction ocean-themed picture books that represent the GSR. These texts were selected based on an in-depth analysis of the ways in which the text and illustrations accurately communicate marine science concepts to the reader (Freitas et al., 2023). The classroom teacher and school supplied additional resources that formed the weekly ocean-themed activities that were implemented in the classroom. The research team supplied the drawing materials that included A4 artist paper, coloured soft pastels, and pencils.

The marine science programme was conducted over a three-month period, from June to September 2022 in one classroom that included a mix of both grade 3 and 4 students (aged 8–10 years old). The classroom teacher integrated ocean topics at least once a week in their lessons based on guidance from the teachers' guide (Freitas et al., in review).[1] Some example activities that were conducted, included reading and discussion of ocean-themed picture books that represented the local marine environment, creation of a map of the GSR and artwork to decorate the classroom walls, and creation of identification cards for local marine organisms as a way to increase students' familiarity with the marine life found on the local rocky shores. In addition to the weekly activities implemented by the classroom teacher, the research team also visited the school to conduct ocean science activities. This involvement included two classroom activities and one excursion to their local coastal environment.

To determine the students' attainment of learning outcomes, the researchers obtained drawings before and after the marine education programme as well as conducting small, focus group interviews to discuss the drawings with the students. For both these before and after drawings, students were asked to 'draw a picture of what you would expect to find if you were snorkelling on your local beach'. The pre-and post-drawings were evaluated quantitatively by a marine science educator and an experienced arts-based researcher following methods developed by Bowker (2007) and later modified by Cainey et al. (2012). Individual evaluation of breadth, extent, and detail were conducted by both researchers and then results shared and discussed.

The pre and post drawings were also analysed qualitatively in conjunction with the transcripts of the interviews. The students were interviewed about these drawings a week later, respectively. This involved students' being invited to participate in a focus group discussion with groups of 3 to 5 children, where they had the opportunity to offer contributions about what was included in their drawings and why. The interviews were important to clarify some of the correct species in the students' drawings as well as their reasonings about why they included particular features and subject matter and the compositions of their drawings. To capture the multiple perspectives of the students and their reasoning for including images (knowledge, time and materials) or depicting images (style and materials), thematic narrative analysis was conducted (in addition to the quantitative analysis). Group interviews were conducted in a meeting room with their classroom teacher present and were audio recorded and transcribed for analysis. The drawings were photographed with ethics permissions approved.

Pseudonyms were used to de-identify students, teachers and places mentioned in interviews. The three researchers were coded as R1, R2, and R3 (in no particular order in relation to the authorship of this paper).

Analysis

In the quantitative phase of analysis, the pre and post drawings were analysed by scoring across the three categories; breadth, extent and detail. The scores from each category were then added together for each drawing to achieve a mastery score overall for each drawing. These scores were then compared between pre and post drawings. Breadth corresponds to the 5 themes identified in the drawings in relation to the presence of fish, non-fish marine animals, humans, habitat and surrounding environment (e.g., air). Each theme in the drawing received a score of 1. Extent was scored in relation to the number of different species of animals in the picture to a maximum score of 5. A negative score was given to species in the incorrect environment (e.g., clownfish in the GSR). Detail was scored between 1 to 5 according to the level of accuracy in the pictures as per Cainey et al.'s (2012) method. Accuracy was assessed in terms of the representation of marine organism with distinguishable features, the

1 Freitas, C., Hannigan, S.M, Bellgrove, A., Venzo, P., and Francis, P. (in review). *Diving into a sea of knowledge: Empowering primary school students in ocean literacy and raising awareness of the great southern reef.*

correct use of colours, the representation of ecological relationship between organisms and their habitat (e.g., animals hiding from predators and hunting for food) and the attribution of human emotions to animals (anthropomorphism).

The qualitative analysis emerged when the two researchers (when undertaking the quantitative analysis) found they needed to note down their aesthetic responses such as the techniques or style some students used to depict moving water, dark kelp forests, juxtaposition of scale or different types of perspective used. On the occasion where the two researchers came up with different estimates of species depicted by the students in their drawings, there were realisations that qualitative and aesthetic interpretations of some drawings (the placement of fish, seaweed or goggle frames in the picture plane etc.) differed and therefore added further understandings to the former quantitative analysis. The two researchers had made separate notes about their aesthetic responses and interpretations as well as other comments that had been decided from their qualitative analyses. Often these different interpretations were due to abstract drawings of species or unusual perspectives (such as a tail on the edge of the page). Conversations between the two researchers were important to discuss the different interpretations and raised the issue of aesthetics when using the arts—particularly drawings in educational research for teachers, researchers and students. Referring back repeatedly to the interview transcripts often helped confirm what the students meant or were trying to communicate through their drawings and the role of the researcher. For example, Figure 1 shows two fish drawn in a similar way, yet one is coloured purple and the other orange. These different colour variations suggested they could be different fish species or could also be the same fish species. In Figure 2, Peta has drawn a blue fish tail disappearing off to the right of the page. The researchers had to do a bit of guess work figuring out what this could potentially be based on its position on the page, its form, colour and the way it was drawn in context to other elements on the page. These different aesthetic observations and interpretations highlighted the need to conduct a thematic and aesthetic qualitative analysis into both the drawings and interview data.

Results

Thematic nodes

An analysis of all the interview transcripts ($n = 13$ students) following the students' first drawing, revealed the 8 thematic nodes based on a wide range of aesthetic responses and uses in the interview dialogue and in connection with the first drawings (see Table 1; nodes 1–8). The nodes are ordered randomly in Table 1 and represent no particular sequence of preference or frequency of nodes.

An analysis of all the transcripts following the students' second drawings, found the above 8 nodes as well two additional thematic nodes 9 and 10 (Table 1). These 10 nodes represent a diversity of aesthetic experiences (from both the learner and researcher), types of responses and reasonings for the aesthetic occurrences in the data. They emerged from searching for aesthetic experiences generally rather than a particular criteria such as 'students' accounts of aesthetics' or 'researchers use of aesthetic languages' because we started to see overlaps with aesthetic occurrences in the data early on. We could identify multiple themes in some statements of researchers and of students so we did not want to just present aesthetic experiences of children's learning separately because (1) this would not be true to each set of narratives as a whole, and would take the narratives out of context, (2) we could identify numerous

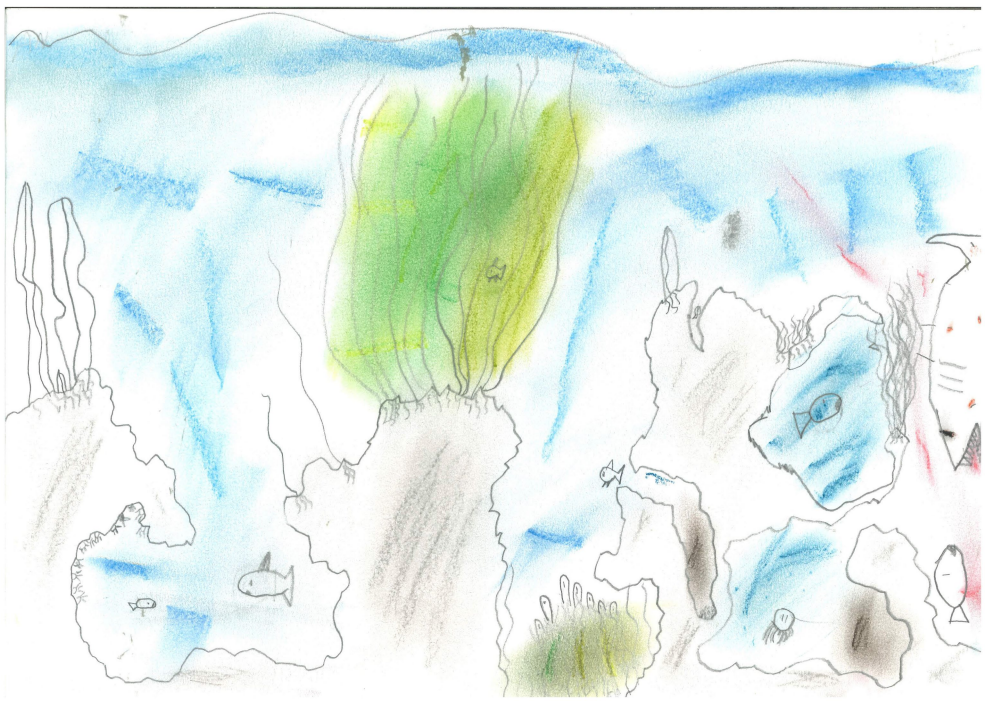

FIGURE 1
Joe's 2nd drawing.

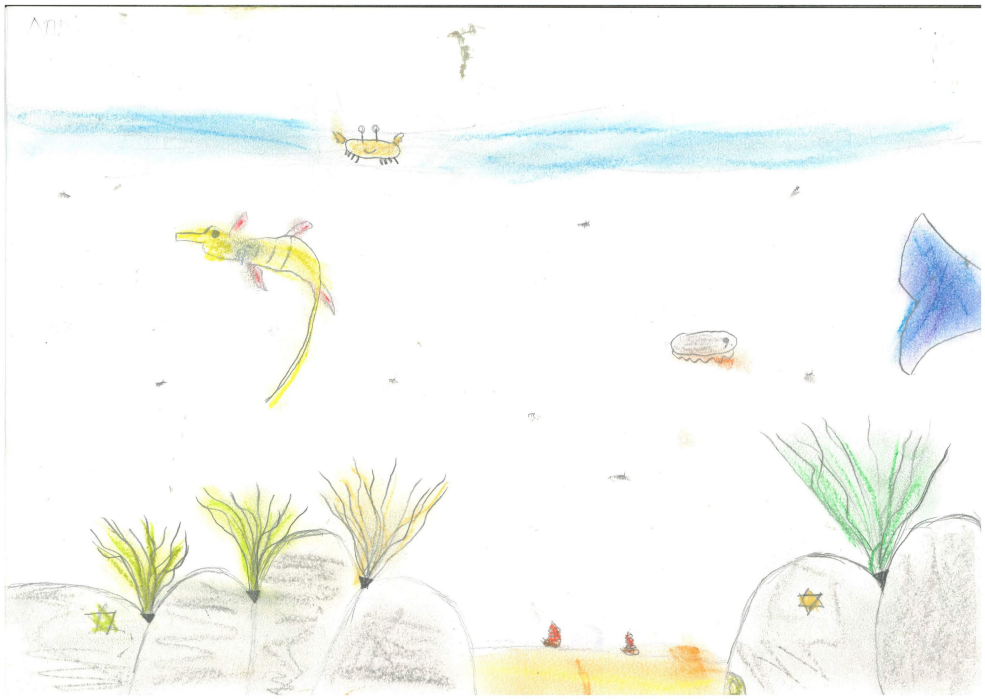

FIGURE 2
Peta's 2nd drawing.

TABLE 1 Thematic nodes based on aesthetics from pre and post student's drawings following a marine education programme.

The 10 thematic nodes:	Example from transcript
1. Aesthetic experiences and communication	**Joe:** And it felt really, hmm.
	R1: Like sandpaper?
	Joe: Slimy.
	R1: Ah slimy. Lucky you, that sounds like a good adventure.
2. Researchers checking student learning/knowledge	**R2:** And the decorator crab is here.
	Joe: I cannot really see it.
	R1: Well, that's the point, is not it? Because the decorator crab must be camouflaged.
	R2: It means you drew it really well.
3. Researchers prompting students to think a bit deeper/explore what they already know (e.g.,: So, you have looked under the ocean. Do you think that what you saw there, might be similar to what might be out here?)	**R2**: So, is the eel hiding in the hole as well?
	Rob: Yeah.
	R1: Yeah, it is almost a very camouflaged this one, whereas this one is still hiding, but you can see a little more, because of the colours you have put there. I like the idea of the mask too.
	R2: Me too, really great idea.
4.Students/artists non-comital about their drawing—a kind blaming lack of ability or not sure about what they were supposed to draw? Or shifting away from being judged/assessed?	**Joe:** The shark mouth, this one looks a bit weird [first drawing], but this one looks a bit better [second drawing] … and the seaweed.
	R1: Yeah, so you have got bigger seaweed in your second picture, do not you?
5. Using knowledge or familiarity with or experiences of place (local names/ identity with place/ knowledge of place etc.)	**Joe:** Excuse me, this is not around here, but I remember when I went up to SeaWorld, no, not SeaWo…, I think… sorry, hmm. And I went to the stingray area, and there was this stingray that was half shark half stingray and I got to feed it.
6. Students explain visual language such as design elements (incomplete colouring) to clarify 'correct' depiction of marine environment (as was required by the project)	**Joe:** I tried to make a different colour with the red and blue, but it did not turn out good the first one.
	R1: So it looks like you have a bit of experimentation with the pastel as well, at the same time, which is great.

(Continued)

TABLE 1 (Continued)

The 10 thematic nodes:	Example from transcript
7. Researchers explain/use visual language to guide the student through the composition & layers of the marine environment.	**R1:** Talk us through what you have got there Peta, what's up the top, what's in the middle and down the bottom there. Because I can see a lot of different things. **Peta:** At the top is like kind of like this purple sledgy stuff, and then there's some birds and then down the bottom is like the ocean, and what I can see down there is pink shells and like rock and fishes and blue and green ocean.
8. Association to popular culture (books, films).	**R1:** And I think what I've also started to see is that you have got a few different other animals present in your second picture too, that… One, I guess, picking out the sea star and picking out the sea urchin, where did you learn that might be sea stars or sea urchins on the GSR?
	Alice: There is a rock pool book.
	Rob: 'Rock Pool Secrets'?
	and another example:
	R1: That's ok. And the East Australian Current, when did you pick up that it exists?
	Peta: When I watched 'Finding Nemo'.
	R1: Ah, the EAC. And so how did you know that a crab potentially might be something that would travel in the EAC?
	Peta: Because in Nemo I saw all like the turtles going in and I did not know where to put the crab, because I did not want to put it down here, so I just draw the EAC and put the crab in there.
9. Seeking insight into learning comparing first and second drawing.	**R1:** So, the sea stars, is that something you have seen more of this term as well?
	Peta: Yeah.
	R1: And so, where have you seen the sea star or learned about the sea star?
	Peta: I learned about the little green sea star when we did the…
	Rob: The ID cards?
	Peta: Yes, the ID cards.
	R1: Sounds like the ID cards were pretty fun.
	Rob: Yeah.
	Peta: Yeah.
10. Researcher/educators clarifying with students their learning (comparing first and second drawing – also including here clarification of 'names')	**Referring to Peta's 1st drawing,** Figure 4 **and 2nd drawing,** Figure 2:
	R1: And I've noticed you mentioned you have got holdfast in your second picture.
	Peta: Yeah.
	R1: Which I'm looking at your first one, can you see if there is any holdfast?
	Peta: No,
	R1: Is that something that you have learned during the term?
	Peta: Yeah
	R1: And where did you learn the term 'holdfast'? Do you remember how you learned about that?
	Peta: At the start of the term, we were all learning about kelp, and I saw one of those at the beach, and I started swinging the seaweed around.
	R1: Fantastic.
	R2: We have also seen it when we went down to the beach, did not we?
	Peta: Yeah.

Student names have been changed for anonymity and R1 and R2 are the interviewers from the research team.

examples of influence such as researchers using aesthetic language which potentially influenced the way students thought or spoke about their work, (3) we could see that aesthetics is embedded in subtle and surprising ways through the relationships of teacher/researcher/students, artefacts create, experiences, connections to place, style and more. In line with the holistic approach of narrative and arts-based inquiry, we appreciated the whole message being communicated, rather than drawing conclusive understandings from parts of texts.

Josselson (2011) explains that 'it is not the parts that are significant in human life, but how the parts are integrated to create a whole' (p. 226).

We therefore share this full list of 10 thematic nodes here to reveal these findings from early on in our qualitative analysis.

Images of the six students' drawings (a before and after drawing for each student) are provided. Their quantitative analysis scores are presented below to show the differences between pre and post drawings—particularly in relation to including more correct species in their second drawing than in the first drawing:

Joe's 1st drawing (Figure 3).
Quantitative score:12 (breadth:5; extent:4; detail:3).
Joe's 2nd drawing (Figure 1):
Quantitative score:13 (breadth:4; extent:5; detail:4).
Peta's 1st drawing (Figure 4):
Quantitative score: 10 (breadth:4; extent:3; detail: 3).
Peta's 2nd drawing (Figure 2):
Quantitative score: 14 (breadth:4; extent:5; detail:5).
*Rob's 1*st *drawing* (Figure 5):
Quantitative score: 8 (breadth:2; extent:4; detail: 2).
Rob's 2nd drawing (Figure 6):
Quantitative score: 14 (breadth:5; extent:5; detail: 4).

As our discussion for this paper is based more on the qualitative and aesthetic analysis of the methods used, we focus our results and discussion on four findings from Table 1, based on the three student data sets of drawings and analysed transcripts:

1. The need to acknowledge the aesthetics of the drawings in conjunction with words and meanings.
2. The aesthetic experiences and communication.
3. The role of aesthetics in student learning evident in the children's reasonings about their drawings and subject matter.
4. Student's place experience.

The need to acknowledge the aesthetics of the drawings in conjunction with words and meanings

The analysis presented in Table 1 clarified to the researchers that those conducting the interviews used aesthetic language (see thematic node 1, 2, and 3 in Table 1) to encourage the students in their drawing ability, confidence and provide re-assurance. This was important given that the focus of the research was about students recording knowledge of correct species and correct representations of their surrounding environment in their drawings and that a number of students were found to be making 'excuses' for their drawing ability (Table 1, thematic node 4 and Table 2, line 3). These excuses could be viewed on the one hand as depicting the correct species in the correct way and therefore being right or wrong in their assessment, and on the other hand about insecurities about their actual drawing ability as in this example with reference to Joe's first drawing (Figure 3):

R2: And you said this is a great white? Joe: Yes, I did its mouth a bit weird though.
R1: Well, that's hard is not it to draw a fish? You've all done a wonderful job. Joe: And the smudging, I did not do a good job.
R1: Yeah, it is hard to do the smudging. You've done pretty good though. Came out really well.

FIGURE 3
Joe's 1st drawing.

FIGURE 4
Peta's 1st drawing.

During the first phase of analysis when drawings were assessed quantitatively, we had realised that we also needed to consider some of our own aesthetic contributions to the research process such as clarifying and checking our own interpretations of what students were communicating in their drawings, against the transcripts. We also made our individual notes about some of the uniquely aesthetic ways in which each student recorded, depicted, represented, and therefore understood the marine environment and species in their drawings. These notes were helpful at this quantitative analysis stage to be more conscious of our interpretive thinking through the writing process of researchers' note-taking, then being able to share these excerpts with each other. This practice was derived from 'bracketing out' when conducting phenomenological research analysis. This bracketing out our own assumptions through journal or diary writing was put forward by Moustakas (1994) as a way to express and make more conscious our own interpretations and assumptions, so they do not subconsciously start to influence our researcher interpretations and analysis. A case in point is with reference to Figure 5, Rob's 1st drawing and the comments that the two researchers made following their quantitative analysis of this drawing:

R3's analysis noted that: Interesting perspective through snorkel goggles. I like how the drawing of the black round fish can be seen. It's as if they started drawing it big then decided to make it smaller (maybe thinking of things in proportion to each other?) Or is this sketchy drawn circle an air pocket of some description they have learnt about? I love the little fish coming out of the rock and the coloured thing that seems to weave or lie behind the plankton on the right.

R2's analysis noted that: This is a great drawing, and all the marine organisms have distinguishable features. In terms of the marine habitat, the variety and strong colours used indicate a representation of a tropical marine environment, rather than a temperate one.

Whilst such reflective notes on this example, did not counter the quantitative analysis, it did reveal to the researchers that differing interpretations and individual aesthetic responses, combined with the unique style of each child's drawing, needed careful consideration to really understand what the students recalled and learnt during their marine education programme. It was important to consider some of the children's reasons for placing marine species where they did in their drawing, depicting them as a particular size compared to others, and their use of words (labels

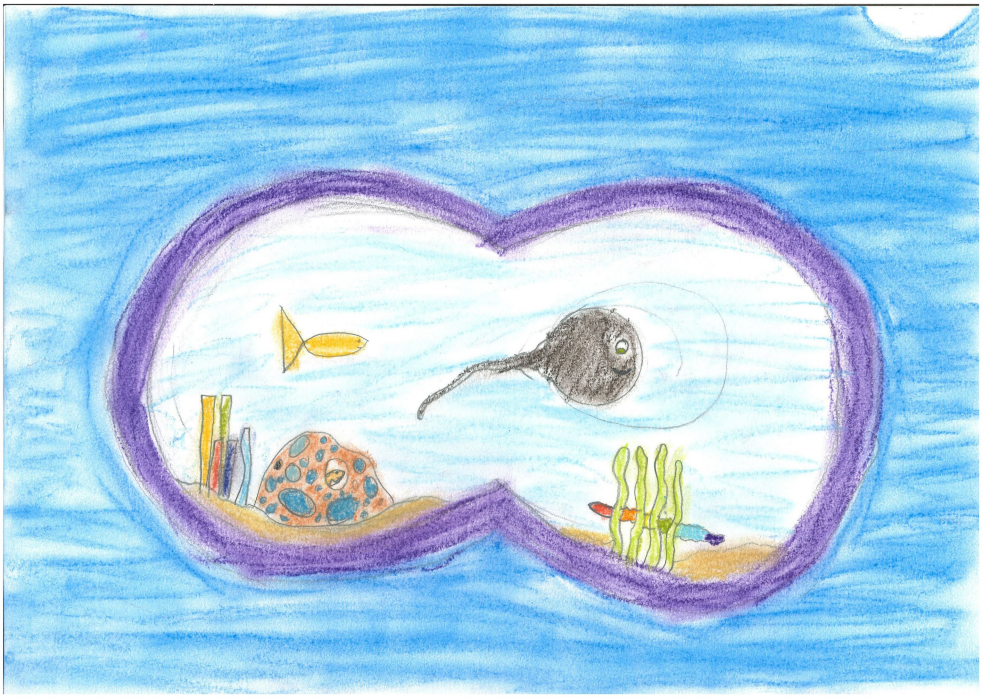

FIGURE 5
Rob's 1st drawing.

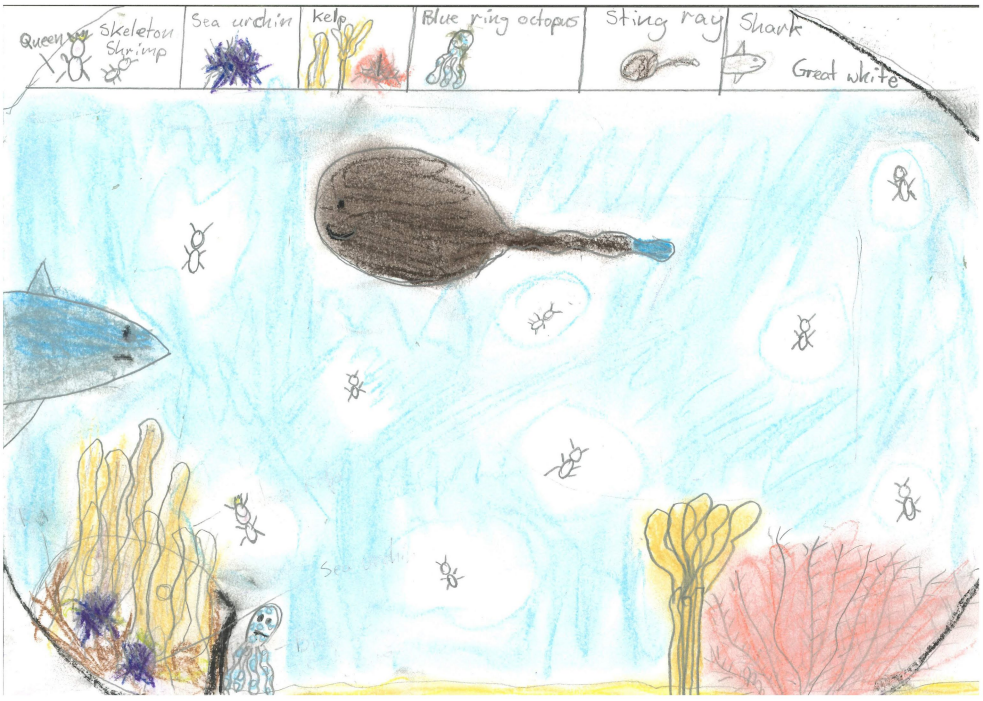

FIGURE 6
Rob's 2nd drawing.

and descriptions). Examples of this are seen within Rob's drawing and interview (see Figure 6; Table 3, line 38) and Joe's drawing and interview (Figure 3; Table 4).

What the research analysis here required was a little like Tinio's (2013) Mirror Model of Art whereby the aesthetic experience of someone perceiving an artwork can be in reverse order of the steps the artist took during their creative artistic process. This could also be understood in terms of the model presented earlier of (H), (I), and (E). Tinio's (2013) concept involves understanding layers of materials that go together to create the final result, starting with an initial idea

TABLE 2 Rob's 1st interview.

1	*Rob: So, I have like the snorkel surrounding and that's just the ocean, and that's in*
2	*the ocean and there's a stingray. I tried to make it a bit cartoony because I don't want*
3	*to make it real, because it's hard to draw.*
4	*R1: Fair enough.*
5	*Rob: And then I have two eels here, one's in seaweed, and there's one in this little*
6	*rock thing like (referring to another student's drawing), with all these holes, and then*
7	*there's just a fish there and then some coral and seaweed.*
8	*R1: So this is, over here—some coral and seaweed?*
9	*Rob: Yes*
10	*R1: Yeah, fantastic.*
11	*R2: So, is the eel hiding in the hole as well?*
12	*Rob: Yeah.*
13	*R1: Yeah, it is almost a very camouflaged one this one, whereas this one is still*
14	*hiding, but you can see a little more, because of the colours you've put there. I like the idea of the*
15	*mask too.*
16	*R2: Me too, really great idea.*
17	*R1: And have you snorkelled out here before?*
18	*Rob: No, never snorkelled.*
19	*R1: So, this is what you imagine you might see.*
20	*Rob: Yes. I've snorkelled like out of Australia, but not in Australia.*
21	*R1: Aww, lucky you, that sounds like a real adventure that one.*
22	*R2: Is this similar to what you've seen before while snorkelling?*
23	*Rob: Hmm, no, not really.*
24	*R2: So, this is what you imagine it would be down here?*
25	*Rob: I just draw what I might see.*
26	*R1: Brilliant, love it. Thank you for sharing.*

in reverse order. Vartanian (2017) suggests this model has the potential to bridge 'the gap between psychologies of creativity and art appreciation' which 'will contribute to the challenge of explicitly contextualising art appreciation by linking viewer characteristics to the intentions of the creator—in reverse order' (p.29). This applies to the children's drawing in this project as they had an intention for their drawing (which was based on the prompt 'draw a picture of what you would expect to find if you were snorkelling on your local beach') and knew they were being assessed on correct species contained in their drawings.

As the researchers were looking for correct and incorrect species depicted in the student's drawings, the researchers were viewing, interpreting, judging and understanding the drawings with this shared intentionality in mind.

Like the scholars above Dewey (1934) also believed that to understand art requires 'discovering the nature of the production of works of art' (p. 11). Gulla (2020) notes how,

> Through their own creative expression, students enter into a transaction with the works of art they are studying. A good deal of the questioning and discussion process involves understanding how the choices made by an artist, writer, musician, dancer, or filmmaker comprise the aesthetics of their work. These discussions of aesthetics help students recognise their own agency in creating work in which they are truly invested (p. 209).

Although this example might relate more to students of art classes, it was important in the interviews to gain an understanding about student's reasoning for the subject matter, perspective and compositions of their drawings and the processes students went through to build these drawings up, from their interviews. Evidence of rubbing images out (see Figure 3) or attempting to colour in a small drawn fish with chunky chalk-pastel (see Figure 6), revealed stages of such creative processes. Interview transcripts offered the researchers further insight into how and why the drawings were created in these particular ways and to clarify some of the subject matter within the drawings from these creative processes.

Furthermore, the conversations in interviews were important in context to the aesthetic dimensions of drawings, for students to clearly show their learning. An example of this is in Table 3 (lines 24–27) where Rob communicates that he had learnt the actual correct colours and was able to include this correct information in his second drawing compared to his first drawing.

The aesthetic experiences and communication

The use of words and images in this research process included children communicating their knowledge and what they learnt, but at the same time communicating aspects of their environment and related activities such as holidaying in other marine environments, snorkelling in other locations, boating and fishing with their parents at their local pier. As the interviewers were also the researchers who taught them on field trips and in some of the classroom workshops, the interview transcripts and drawings that accompanied these could be seen both as part of the science/art education experiences for students as well as forms of assessment. This dynamic could be understood in terms of 'language games' (Wittgenstein, 1967, cited in Wickman, 2017, p. 22) with art. Wickman (2017) explains 'language is action and part of shared activities such as buying clothes, travelling on a bus, or for that matter taking part in science class' (p. 22), language games 'can be seen as habits, customs and institutions through which meaning happens' (p. 23).

An example of the 'language games with art' can be seen in Rob's explanation of his first drawing (Figure 5) and the researchers attempts to understand his 'words' and his drawn imagery (Table 2, lines 1–15).

This Table 2 transcript reveals the aesthetic experiences and ways of communicating by Rob (e.g.,: lines 1–3). It also shows aesthetic use of language was used by the interviewers when encouraging (e.g.,: lines 10 and 26) and validating (lines 13–16) this drawing for Rob.

With reference to Joe's first drawing (Figure 3) below, RI reinforces how well Joe has drawn the decorator crab in its correct environment re-iterating the factual knowledge 'the decorator crab must be camouflaged'. R2 follows this up with an encouraging statement about Joe's drawing ability and the correctness of the species, 'It means you drew it really well'.

These transcripts offer insight into the way the interviewers (who had also taught them some of this knowledge) were inquiring about the students learning and getting each student to use words in conjunction with the drawing content, to confirm this learning. Bringing the drawings and words together around this common purpose of learning about the marine environment allows the aesthetic experiences, expressions and knowledge to come through. It offers insights to student learning that we would otherwise not

TABLE 3 Part A of Rob's 2nd interview.

1	*R1: All right, Rob, you want to explain your second drawing for us, please?*
2	*Rob: Yes, I have some skeleton shrimps just everywhere, basically.*
3	*R1: Yeah, wow!*
4	*Rob: I also have a great white shark over here… a stingray, some golden kelp on the*
5	*rock shore. I've got some sea urchins and a blue ringed octopus and some bull kelp*
6	*and coralline kelp.*
7	*R1: Ahhh, coralline. And tell us what you have got at the top of the picture there.*
8	*Rob: Oh, just like all the species that are down here. Instead of like naming them*
9	*down here, I just put them up there.*
10	*R1: So, it is like a key?*
11	*Rob: Yes.*
12	*R1: Fantastic.*
13	*R2: Really good.*
14	*R1: And so, in terms of… I see there's a couple of things that is mentioned twice in your picture… the stingray. Can you explain to me why you sort of kept that in there*
15	*this time around in the second picture?*
16	*Rob: Because, at the start I knew there were stingrays like in (town name), but now I*
17	*actually know that there's stingrays in the GSR.*
18	*R1: Sounds like the stingrays are quite iconic for the (town name) pier, yeah?*
19	*Rob: Yeah.*
20	*R1: And so, looking at your picture, because you did the drawing through the lens of*
21	*a snorkel mask, have not you?*
22	*Rob: Yeah.*
23	*R1: So, this time around, what differences do you see that you have changed?*
24	*Rob: I did not do like… just play around with the seaweed and the eel. I did the actual*
25	*colours and I knew the actual colours, and… yeah, that's…*
26	*R1: I think it's a lot more specific in terms of the animals and the creatures you have*
27	*drawn.*
28	*Rob: Yeah.*
29	*R1: Because I see you have got the fish in your first drawing, but whereas now, this time*
30	*when you explained your drawing, you said 'this is a great white shark, this is a blue*
31	*ringed octopus, this is a skeleton shrimp' You've given names to what you have drawn*
32	*this time around.*
33	*Rob: Yeah.*
34	*R1: And do you think that's from something that you have learned?*
35	*Rob: Yeah.*
36	*R1: So where would have you may pick up those names?*
37	*Rob: I've got the skeleton shrimp from the ID cards.*
38	*R1: Ah, yeah.*
39	*Rob: And the stingrays I always knew, the blue ringed octopus, I knew they were in*
40	*Australia, but I did not think much of them, and when I went away on my trip, I learned*
41	*more about them.*
42	*R1: Fantastic. And what about the kelp and the seaweed you mentioned before? Did*
43	*you learn more about those?*
44	*Rob: Yea, I learnt them sort of when I came back from my trip.*
45	*R1: Ok, fantastic.*

TABLE 4 Joe's interview with reference to his first drawing, Figure 3.

1	*R1: I also noticed you even labelled some of the things you've got here. You*
2	*labelled the crab and the crayfish too I see.*
3	*R2: And the decorator crab is here.*
4	*Joe: I can't really see it.*
5	*R1: Well, that's the point, isn't it? Because the decorator crab must be*
6	*camouflaged.*
7	*R2: It means you drew it really well.*
8	*Joe: that's why I labelled it. Everyone would think that it's just pile of*
9	*seaweed but it is where the animals live.*

be aware of. As Wickman (2017, p. 23) notes, we 'need to be given agency and act in relation to purpose to be deemed to have learned anything of value by others and ourselves'.

The role of aesthetics in student learning was evident in the children's reasoning about their drawings and subject matter within these drawings

Learning involves change over time. The two drawings created before and after the educational programme for each student were a way to see and hear evidence of this student learning across time. In

Rob's 2nd interview about his 2nd drawing (Table 3; Figure 6) he explains and names the different species more confidently than in the first interview (Table 2, lines 37–45). He is also able to explain where he learnt this from (he mentions The ID cards and also reflections from going away on holiday and coming home again)—see Table 3 line 38. It is possible that without the drawing experiences, and reflecting on the drawings through these interviews, that we as researchers or the children might not have the opportunity to reflect on these diverse aspects of their learning. It seems having the drawing in front of them, and prompts by the researchers, provide opportunity for each child to talk about these multi-modal experiences that all contribute to their learning over time.

At this interview about his 2nd drawing, Rob is able to explain why fish, kelp and other species are placed on his drawing composition, in connection or relation to each other—therefore presenting both contextual and aesthetic knowledge about his learning of the marine environment. From the transcript in Table 3 Rob explains, 'I have some skeleton shrimps just everywhere' (line 2). This suggests his understanding of how shrimp might appear in the ocean 'everywhere' (as opposed to sitting on a rock or floating on the top of the sea) and also not in a regular patterned 'school formation'. This shows how Rob has captured this knowledge and image as a formal element of his drawing; pencil-drawn creatures randomly placed on the page surrounded by white. Whilst this 'form' is not factually correct, we can understand the different drawing-treatment of shrimp from the way other species are drawn and coloured (fish, seaweed, rocks), as differentiated from other species. Making something look different by using a different drawing technique can be a way to show knowledge and learning.

The quantitative analysis of how many species were correct in the drawings was complimented by checking where the student had learnt particular knowledge or information and to confirm more learning had occurred when comparing the 1st drawing to the 2nd drawing. Rob's two drawings, and the above transcript show that a progression and accrual of knowledge took place over the course of the project. The student's knowledge and experiences of the two different locations of tropical waters in the north of Australia (where 'Nemo's' exist and where some students holidayed) and the GSR, needed to be teased out in this research process and it was important for the researchers to identify this and address it. For example, it was found that students had less tropical fish, turtles and coral species in their second drawings than in their first. This accrual of knowledge evident from the first drawing to the second could be seen in this example.

Student's place and experience

As discussed earlier, the place was an important consideration given the research was focused on a specific region of the world (the GSR) and therefore it made sense to teach and research with the children who lived near this marine environment. The research revealed that most of the students were experienced with their local ocean environment through surfing, snorkelling, fishing and exploring the rock pools and seashore. With reference to Table 2, Rob's 1st interview, even though Rob had not snorkelled in Australia or at his local beach, he had snorkelled in other parts of the world, and used that experience to depict this perspective through the shape of snorkel goggles. Within this goggle frame (Figure 5) he visually expressed and depicted what he 'might see' from his learning of his local marine environment. The prompt from the marine science researchers for the students' drawing tasks had been 'draw a picture of what you would expect to find if you were snorkelling on your local beach'. The word 'imagine' was not used so it was interesting in the transcript of Rob's 1st interview (Table 2), that he did not use the word 'imagine' as the researchers did, instead choosing the word 'might'. This could be understood as 'you cannot always see what you hope to see when you snorkel—chance plays a part in what marine species you could actually put into this drawing perspective through snorkel goggles at any one time'. This is because the ocean, through currents, is always moving therefore the use of the word 'might' is applicable in this context. This of course also relates to word games with art as mentioned earlier.

Place and experience (Malpas, 2018) was also evident in the following transcripts where Rob is discussing his second drawing (Figure 6). Table 3 excerpt shows how learning about stingrays has taken place in the local environment of the student and how the new knowledge he has learnt enhanced his knowledge about local marine species. He is also able to make connections with studying the ID cards and his trip away to other places (see Table 3). This raises the issue of how this kind of programme might work for communities that are far away from a marine environment. Singhal (2019) writes about a 12 h trip that 40 students from far west NSW took to visit the beach: 'For many of the Aboriginal students from Brewarrina, Weilmoringle, Bourke and Goodooga, it was their first time seeing the ocean' (n.p). Whilst it is possible that a taste or interestedness in a topic may not necessarily be connected to what you are already familiar with, the ability of students to reflect on contrasting environments as part of their learning in this study, shows how the strategy of depicting before and after drawings in and out of one's environment or place, over time, are beneficial for students to engage in reflective learning and provide evidence of this as has occurred in the drawings in this study. As most of the arts involve the body in spaces and places and doing things (Brook, 2008), the body is an important consideration of this research and the learning experiences children had. Rodaway (2005) explores the body as a 'sense organ' in place, which is a reminder that place is a sensory experience (Tuan, 1977) as well as an aesthetic experience. Remembering and recalling knowledge and places are also important. As Casey (2001) points out, the body remembers: 'the lingering of place in body once it has been established there by experience' (p. 719) which also has an impact on learning.

Discussion

We have shared in this paper the design and implementation of this marine education programme with a focus on the methodology and methods used. We have discussed some of the findings of disciplinary aesthetics where the focus was marine science incorporating art and narrative. This research resonates with Krechevsky et al.'s (2013) statement that 'the beliefs that learning is purposeful, social, emotional, empowering, and representation provide a pedagogical basis for making learning and learners visible' (p.58). Specifically, this was achieved through focusing on children learning about their local marine environment initiated by professional researchers as teachers, and empowering environmental stewardship.

Whilst art (drawing) was primarily used to get students to draw, compose, express and present their learning, the anticipation to conduct the drawing activities and then engage in creating the drawings, were

also part of the learning experiences. Art was not used embedded in the science teaching experiences to the extent it could be, such as in drama where stem cells are enacted in embodied and social ways (White and Raphael, 2023) or lab experiments documented through drawings, photographs during scientific experiments (Evagorou et al., 2015). However, the opportunity to combine: experiences of environment, place, reflecting on own lived experiences, propositional and non-propositional knowledge, creating pre and post drawings then talking about these, involved learning in aesthetic and multi-modal ways. Drawing their knowledge and being able to discuss these drawings, were some of the ways students' learning in this project became visible as we could see their development within each drawing and through comparing both drawings as well. Our analysis shared in this paper shows how we need to consider the aesthetic implications of such visible learning opportunities at intervals and during the process of an educational programme in both teaching and research.

For the pre and post drawings used in our methods, it is important to note that there wasn't a restrictive template to use, or (as there might be in art classes) a limitation of a colour palette or a stylistic criteria, that students were required to meet. This is an important distinction to make in the design of these lessons and the assessment process of the drawings. The alternative would have been to have templates where children draw and fill in species, which would have been less of an aesthetic (and potentially enjoyable) experience for the students but probably easier to analyse quantitatively. We believe that enabling students to draw in an expressive and aesthetic way, rather than merely illustrate what is already out there, or fill in a template, can actually generate more insight into student learning, provided the time and considerations of interpretation, is put into understanding what the students mean by their imagery. Enabling students to have more aesthetic experiences, present their own unique perspectives (goggles on Figure 5) and their own stylistic preferences (as can be seen by the different styles of each drawing) may be potentially harder and complicated to understand and analyse but provides more insight into children's different perceptions and multi-modal learning.

As this special issue will reveal, in both teaching and research, aesthetic experiences can be hidden and they are useful to go searching for to understand education better. We have shown examples of the individual aesthetic experiences for the child participants as well as the researchers and how important these were to understand more about how and what the children learnt and the important role of aesthetics and interpretation for all involved. The aesthetic language the students and interviewer/researchers used, as well as the aesthetics of each drawing (style, mood, composition, perspective, scale, colours, tone theme) are highlighted in this paper to show the value of providing aesthetic opportunities for all involved in teaching and research—particularly when art and language (which traditionally are aesthetic) are combined with other subjects like science to enhance teaching and learning opportunities. Attending to aesthetics in such work can reveal greater insights into learning and the dynamics of relationships between teachers, researchers and students.

We have shared our methodology and methods employed, which helped us to decipher meaning from the data. Whilst interviews in research methods are common, our paper highlights the need to combine interviews or opportunities for students to explain their art when it is being assessed in education contexts and/or in research. When art is combined with other subjects in education or research, students and participants need to be able to explain it and data needs to be interrogated with careful consideration of interpretations. When doing so, researchers in particular need to carefully consider the exchange of aesthetic language through conversation, drawings and words in drawings (i.e., labels) that could influence our interpretations. There are many different interpretations a person could make from a view of the ocean through snorkel goggles—interpretations that could draw on our psychological knowledge, experience, place, prompt and aesthetic choices and preferences. having the opportunity to describe and explain drawings in context to the prompt and the environmental experiences the student (artist) has, allowed the student (artist) to exercise their own aesthetics sensibilities whilst processing, communicating and expressing their learnt knowledge as rob did (see Tables 2, 3, 5; Figure 5). They then allow the researcher or teacher to exercise their own ability to bracket out their own interpretations and assumptions that might be loaded with aesthetic preferences, and really hear and see what the student is learning in a more holistic and place-based/environmental and ecological way.

Place and environment were important to this study. This research has revealed the importance of students learning about local knowledge through drawing, allowing for reflection on their other experiences of the topic (trips away to other marine environments, snorkelling, surfing, fishing at the pier). These more holistic and place-based experiences create opportunity for the learning to be relevant for students' lived experiences and therefore more able to retain the knowledge learnt in a more applied and relevant way. However, as mentioned above, the way students reflected and contrasted their local GSR knowledge, experiences and interest with other place-based experiences (i.e.,: holidaying in tropic regions of northern Australia) and the role of memory and place-based experiences in this, reminds us of the need to provide opportunities for students to make these aesthetic links to other aspects of their lives. This might help them engage and relate more to topics and help them to find a taste or interest in science topics (Anderhag et al., 2015; Anderhag, 2017).

Finally, as a result of the positive outcomes of this project, including an outstanding level of teacher engagement, a new ocean education inquiry unit, focused on coastal sustainability, was developed by the teachers in the school for Foundation to Year 7 students. This exceeded the initial expectations of the research team, particularly considering the main obstacles described in the literature to incorporate ocean literacy in classrooms such as the absence of ocean topics in the school curriculum and teacher's limited understanding of marine science (Gough, 2017; Freitas et al., 2022).

TABLE 5 Part B of Rob's 2nd interview.

1	*R2: Rob, can I just ask one more thing?*
2	*Rob: Yeah*
3	*R2: I think I remember from the first drawing that you mentioned that these*
4	*would be coral, right? This time around, I see that you did not include corals, is*
	that right?
5	*Rob: Yes.*
6	*R2: And also, you kept the snorkel mask, did not you?*
7	*Rob: Yeah.*
8	*R2: It's just much bigger now, and you have much more detail in your*
9	*drawing.*
10	*Rob: Yeah.*
11	*R1: Fantastic, all right, thanks Rob.*

We look forward to hearing how our methods and methodologies shared in this paper are adapted by the teachers for their teaching and assessment processes and the future surprises we might learn about the role of aesthetics in the nexus of teaching, learning and research.

Data availability statement

According to the conditions of approval to conduct this research, in the case that access to the data is requested, the individual(s) seeking access require permission granted from the data custodians in addition to Human Ethics approval from the relevant institution(s). Requests to access the datasets should be directed to Prue Francis prue.francis@deakin.edu.au.

Ethics statement

This study was reviewed and approved by Deakin University Human Ethics Advisory Group (Project #SEBE-2021-45-MOD04), Department of Education and Training Victoria (2021_004505). The participants and/or appropriate carer/parents of children signed an informed consent form. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. The manuscript presents research on animals that do not require ethical approval for their study. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

SH: Conceptualization, Data curation, Formal analysis, Writing – original draft. CF: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. PF: Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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