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**ABSTRACT**

Museums are increasingly transforming from passive repositories of history and culture into dynamic spaces that facilitate interdisciplinary learning and active community engagement. This shift is evident in the integration of art and science within museum settings, which enhances public understanding of complex global challenges such as climate change. Focusing on two case studies from New Zealand, specifically The Unseen project by Gabby O'Connor and Bottled Ocean 2116 by George Nuku, this article examines how collaborative initiatives between artists, scientists, and communities can cultivate ecological awareness. These art–science projects provide immersive and experiential learning experiences, making scientific data more accessible and emotionally resonant for diverse audiences, particularly students and community members. By actively involving participants in the creative process, these initiatives foster deeper cognitive and emotional engagement, encourage a sense of shared ownership, and inspire collective action in addressing pressing environmental challenges. Based on these two case studies, this article also explores potential challenges in establishing and sustaining art–science partnerships in museums. Additionally, it suggests possible strategies for fostering interdisciplinary collaborations that enhance the integration of artistic and scientific engagement within museum spaces.

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## Introduction

Museums, once regarded as quiet sanctuaries dedicated to preserving history and culture, have undergone significant transformations in recent years. These institutions are no longer just repositories of the past; they have evolved into vibrant spaces that encourage interdisciplinary learning and foster community engagement. This shift is especially visible in the integration of art and science within museum environments, where creative practices are used as powerful tools to address complex global issues, such as climate change. Contemporary research in museum studies emphasizes the growing importance of this integration and the role of art–science collaborations in enhancing public understanding of scientific challenges.

Many scholars have noted that the intersection of art and science offers remarkable benefits. Macdonald and Silverstone[1] argued that interdisciplinary approaches within

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museums can nurture a sense of community and collective responsibility toward global issues. By framing scientific challenges through an artistic lens, museums can inspire meaningful dialogue and action among diverse audiences, bridging the gap between scientific knowledge and public engagement. This dual approach not only educates but also encourages visitors to become active participants in addressing environmental concerns.

Hein[2] underscored the value of a constructivist approach to learning, where knowledge is actively built by the learner through personal experiences. In this context, art becomes an experiential component that aids visitors in constructing their understanding of scientific concepts. By engaging with art installations that depict scientific ideas, learners can explore these concepts in an immersive and hands-on way, leading to more profound cognitive and emotional connections. Hein's opinion illustrated how engaged learning in museums can deepen comprehension and knowledge retention, enabling learners to establish personal connections with the material and making learning more impactful and enduring.

Falk and Dierking[3] supported the idea that incorporating art into science exhibitions enriches the experience by providing diverse sensory inputs and interpretive strategies that cater to various learning styles and preferences. This inclusivity is crucial when addressing complex and abstract scientific topics, where traditional methods may not fully capture the public's interest. Their research stressed the potential of museums to foster lifelong learning, engaging visitors in ways that extend beyond conventional exhibit formats.

In addition to scholars providing theoretical support, artists have also embraced the integration of art and science, producing works that transcend disciplinary boundaries. By interpreting scientific phenomena through art, they bring unique insights that complement scholarly discourse. For instance, Olafur Eliasson created immersive installations that replicate phenomena like outer space, inspiring awe and wonder.[4] These artistic endeavors stimulate reflection on the potential of art–science collaborations to spark curiosity and inspire exploratory thinking. Similarly, Maya Lin's project *What is Missing*? applied scientific principles to create immersive experiences, urging viewers to reflect on their roles in sustaining the natural world.[5] Such projects utilize both the emotive power of art and the empirical grounding of science to provide holistic educational experiences. In a similar vein, two exhibitions from New Zealand, *The Unseen* by Gabby O'Connor and *Bottled Ocean 2116* by George Nuku, demonstrate how interdisciplinary approaches transform museum spaces into interactive learning environments that cultivate ecological awareness. These two case studies will be examined in greater detail in the following sections of this article.

The impetus behind these interdisciplinary collaborations lies in a shared ambition: the pursuit of novel perspectives and insights that neither discipline could achieve independently. Artists are increasingly drawn to the empirical rigor of scientific methodologies, infusing their creative work with intellectual depth.[6] Meanwhile, scientists are recognizing the unique power of artistic expression to simplify complex ideas and connect with a broader audience.[7] MacFadden et al.[8] stated that the merging of art and science not only enhances visitor engagement and learning outcomes but also transforms abstract scientific ideas into concrete and relatable experiences. The symbiosis of science and art unveils the multifaceted nature of human experience, linking the rational to the emotional and the objective to the subjective.

The fusion of art and science within museums presents an interdisciplinary approach to education and public engagement. Through the synergy of artistic creativity and scientific inquiry, museums become catalysts for dialogue and action, empowering visitors to engage actively in shaping a sustainable future. This article explores two New Zealand-based case studies, showcasing how local artists and museums harness the power of art–science collaborations to educate, inspire, and deepen our understanding of our relationship with the natural world.

## Case study 1: Gabby O'Connor—The Unseen

The relationship between art and science has evolved from historical curiosity to contemporary necessity, particularly in museum spaces that seek to engage audiences in pressing environmental issues. *The Unseen*, a collaborative project between artist Gabby O'Connor and marine scientists from the National Institute of Water and Atmospheric Research (NIWA) in New Zealand, serves as an exemplar of this fusion, demonstrating how artistic practice can function as both a communicative tool and a participatory learning experience. Conceived as a large-scale installation, *The Unseen* transformed scientific data into an immersive sculptural environment composed of 12 kilometers of colored rope and thousands of cable ties. Suspended within gallery spaces, the intricate, web-like structure evoked the fragility and resilience of Antarctic sea ice formations, inviting participants to engage both physically and intellectually with the impacts of climate change on marine ecosystems.

Unlike traditional museum exhibits that rely on textual interpretation of scientific findings, *The Unseen* reimagined how data could be visualized and experienced. The project's success lay in its ability to translate empirical research on sea ice thickness, temperature fluctuations, and biodiversity loss into a tangible and participatory form. Rather than presenting climate change as an abstract or distant phenomenon, the installation allowed visitors to physically engage with the structural properties of ice formations and the interconnectedness of marine life. The creative process was deeply intertwined with scientific inquiry, fostering an interdisciplinary learning environment where data, materiality, and artistic expression converged.

### *Interdisciplinary framework: integrating scientific data through artistic representation*

Central to *The Unseen* was the use of NIWA's Antarctic sea ice measurements, collected through field-based remote sensing and oceanographic instrumentation. These data sets, which track the formation, stability, and seasonal melting of polar ice, were directly mapped onto the physical structure of the artwork. Ice thickness variations were represented through differential rope densities, where:

- Tightly woven and dense segments corresponded to regions of multi-year stable sea ice, reflecting long-term ice preservation.
- Looser and fragmented arrangements signified seasonally melting ice formations, illustrating the destabilization of marine ecosystems due to rising temperatures.

- Layered rope stratifications were used to depict thermal layering in the ocean, visually modelling how temperature shifts create distinct ecological zones that affect species distribution.

Additionally, temperature trend data from Antarctic ocean monitoring programs was integrated into the installation's color coding, where

- Cooler temperature regions were represented using deep blue and purple hues, corresponding to historically stable ice fields.
- Warmer water zones, associated with accelerated ice melt and habitat disruption, were depicted with lighter, more dispersed rope structures, symbolizing increasing fragmentation of polar environments.

This empirical-to-visual translation process ensured that the artwork was not merely metaphorical but scientifically informed, allowing audiences to engage with climate research through an intuitive and sensory experience.

### *Pedagogical approach: experiential learning through participation*

A fundamental objective of *The Unseen* was to provide an experiential learning framework that enabled participants to engage with climate science through hands-on artistic construction. The project was structured as a series of interactive workshops targeting school students and community members, conducted both in classrooms and in museum settings. Each workshop, lasting between 60 and 90 min, was co-facilitated by the artist, NIWA scientists, and teachers, ensuring a balance between scientific inquiry and artistic expression.

Each session began with a marine scientist presenting their research on marine ecosystems, species diversity, and the impact of human activities and environmental changes on sea life. Following this, students worked in pairs using rope and cable ties to create abstract representations of their understanding. These individual artworks were progressively merged as pairs combined their pieces into larger collaborative structures. Over time, this process expanded into a large-scale and unified artwork.

The culmination of the project involved more than 60 workshops, engaging 1600 schoolchildren along with their whānau[9] and communities, ultimately incorporating 12 km of rope into the final artwork. This giant collaborative piece was exhibited in art museums, accompanied by open community workshops and follow-up sessions for participating children. Initially developed with the Nelson community in 2018, the artwork was displayed multiple times until its final exhibition in Wellington in 2021,[10] after which it was dismantled. As part of the project's sustainability efforts, the cable ties were recycled, and the rope was donated to schools, community organizations, and aid groups for future use.

Unlike conventional science education, which often relies on passive information transmission, *The Unseen* emphasized active and inquiry-based learning. Students were encouraged to interact directly with climate science data by constructing physical elements of the installation while simultaneously engaging in structured discussions on climate change and ecological interconnectivity. The participatory nature of the

project was reinforced through question-driven exploration, with facilitators prompting students to consider:

(1) How does sea ice grow and shrink over time, and how does this impact species that rely on it?
(2) How can we visually represent climate instability through the materials and forms we create?
(3) If we were to "map" temperature changes over time, what structural choices would best communicate this shift?

These discussions ensured that students moved beyond superficial engagement, developing both conceptual and material understandings of climate dynamics. The hands-on component of the workshops further reinforced embodied learning, allowing students to internalize scientific principles through tactile exploration. Using rope and cable ties, students physically mapped relationships between ocean temperature fluctuations, ice thickness variations, and broader changes in marine biodiversity.

A student reflected on this experience, noting: "the sea has different levels, and some fish can change which level they are on. I wanted to show that movement in my part of the sculpture." Another student acknowledged the structured nature of the ocean, stating, "There are five different layers in the ocean." Expanding on this idea, a third student explained, "There is a layer in the middle of the ocean that prevents animals from moving between the upper and lower depths." These responses exemplify how *The Unseen* facilitated cognitive processing of scientific concepts through tactile and spatial reasoning, reinforcing a deeper understanding of marine environmental dynamics.

### *Impact of art–science collaboration on environmental education*

The role of teachers in the project was essential in ensuring its lasting educational impact. As facilitators, they guided students through pre- and post-workshop discussions, helping them contextualize their engagement with the exhibition. Back in the classroom, teachers integrated related scientific readings and hands-on activities to reinforce key concepts. A teacher reflected on the project's impact, stating, "Students kept referring back to the installation when explaining ice stability and ocean layers in later lessons. They no longer saw climate change as an abstract concept—it became something tangible."

A secondary school teacher stated, "The project enabled students to engage with climate science in ways that extended beyond traditional classroom instruction." The teacher shared that participating in the project had a significant impact on one student's perspective. The student explained, "I realized that art can communicate complex environmental issues in ways that textbooks cannot. Seeing my own artwork used to illustrate marine pollution gave me a sense of contribution to the cause." Another teacher observed that students continued discussing sustainability issues long after the sessions ended, with some even incorporating these themes into their school projects. The inclusion of authentic student reflections and teacher observations reinforces the argument that art-based learning not only deepens conceptual understanding but also instills a sense of agency and responsibility toward environmental conservation. As

O'Connor noted, "By involving communities in the creation of the artwork, we open up conversations about environmental stewardship and collective responsibility."

By blending scientific inquiry, artistic creativity, and guided pedagogical facilitation, *The Unseen* transformed climate education into a dynamic and participatory process. The project's interactive structure ensured that students were not merely passive recipients of information but active agents in their own knowledge construction. The depth of student engagement, as evidenced by both verbal reflections and creative outputs, underscores the effectiveness of interdisciplinary approaches in environmental education.

## Case study 2: George Tamihana Nuku—Bottled Ocean 2116

George Tamihana Nuku, a Māori artist from New Zealand, addresses critical global environmental issues, particularly plastic pollution through his *Bottled Ocean* exhibition. Nuku's project across multiple countries, including Taiwan, France, and New Zealand from 2014 to 2018, united artists, museum educators, students, and the public. The central theme of *Bottled Ocean* examined the pervasive presence of plastic in modern life and its incorporation into natural systems. Nuku emphasized the extent of plastic pollution, highlighting how single-use plastics, especially bottles, have become ingrained in our environment. Nuku invited audiences to reimagine their relationship with plastic and to reflect on how this ubiquitous material shapes the natural world. *Bottled Ocean* offers more than an artistic reflection on environmental concerns (Figure 1); it creates a dialogue that evolved through participant engagement, reshaping the exhibition at each location.

**Figure 1.** Bottled Ocean 2116 at Pātaka Art + Museum.

### Scientific data as a foundation for artistic interpretation

Nuku's installations utilize plexiglass, repurposed plastic bottles, and synthetic materials to construct representations of marine species and oceanic landscapes, emphasizing the extent to which human-generated waste has become embedded in marine ecosystems. His assertion that plastic is now present in all biological systems aligns with contemporary scientific findings on microplastic infiltration in both marine and terrestrial environments. Studies by Thompson et al.[11] and Cox et al.[12] have demonstrated that microplastics are present in ocean sediments and the digestive tracts of marine organisms, raising concerns about their widespread infiltration into aquatic food chains. Cox et al. further highlight that species such as anchovies often mistake microplastics for food, leading to bioaccumulation and the transfer of plastic-derived contaminants through marine trophic levels. In response to this ecological reality, Nuku repurposes discarded plastic bottles into sculptural representations of marine creatures, reinforcing how plastic pollutants have become inseparable from aquatic life.

A particularly striking example of this theme is Nuku's series of jellyfish-like sculptures, crafted from translucent plastic bottles to replicate the ethereal appearance of real jellyfish in ocean waters. This artistic choice highlights a critical environmental issue: sea turtles frequently mistake plastic bags for jellyfish, leading to fatal consequences. Research by Schuyler et al.[13] provides empirical support for this phenomenon, demonstrating that loggerhead sea turtles exhibit similar behavioral responses to plastic bags as they do to gelatinous prey. The visual similarity between floating plastic and jellyfish plays a significant role in this misidentification. Once ingested, plastic can cause intestinal blockage, starvation, and death, exacerbating threats to already vulnerable marine species (Figure 2).

Nuku's work also draws attention to the biological consequences of plastic pollution, as seen in his mutated fish sculptures, which reference documented cases of marine deformities linked to plastic-derived pollutants. Studies have established that chemicals leaching from plastics contribute to significant physiological abnormalities in marine organisms. Rochman et al.[14] found that fish exposed to microplastics accumulate hazardous chemicals, leading to hepatic stress and organ pathology. These findings underscore the far-reaching impact of plastic contamination on marine biodiversity and reinforce the urgency of adopting sustainable waste management practices (Figure 3).

Through these sculptural artworks, Nuku not only visualizes scientific findings but also urges viewers to recognize the profound ecological consequences of plastic pollution and the necessity of protective measures for marine ecosystems.

### Participatory and community engagement

A key iteration of *Bottled Ocean* 2116 was presented at Pātaka Art + Museum, where workshops were designed to provide students, families, and museum visitors with an immersive and hands-on learning experience centered on environmental sustainability. Each workshop lasted approximately 90 min. The final installation was completed through a collaborative effort between the artist and the public over a period of 10 days. Acknowledging the scale and complexity of the project, Nuku emphasized the necessity of collective participation, stating, "I simply cannot create these (the artworks)

**Figure 2.** Jellyfish sculptures.

by myself, not in 10 days."[15] Through guided workshops, participants worked together to assemble repurposed plastic materials, transforming them into an expansive marine-inspired installation.

- Material Transformation: Participants repurposed discarded plastic bottles, cutting them into jellyfish-like shapes. This process highlighted the adaptation of marine species to synthetic waste and underscored the increasing integration of plastic into ocean ecosystems.
- Structural Assembly: Using cords and fishing lines, attendees constructed modular sculptures, symbolizing the entanglement of marine organisms in plastic debris. This stage emphasized the impact of pollution on marine life, particularly how plastic waste disrupts habitats and food chains.
- Ecological Evolution: The final stage involved collaboratively assembling these components into an evolving installation. This dynamic structure visually represented environmental change over time, encouraging participants to consider the long-term consequences of plastic pollution.

To elucidate complex environmental concepts, the museum educators played a pivotal role in facilitating workshop discussions. They crafted guiding questions to engage students, such as:

**Figure 3.** Mutated fish sculptures.

(1) How does plastic enter the food chain, and what are its long-term effects?
(2) What sustainable alternatives exist for reducing plastic waste?

These prompts encouraged students to critically examine the pervasive issue of plastic pollution and consider holistic approaches to environmental stewardship. Reflecting on the workshops, students expressed profound realizations about the environmental impact of plastic waste. A high school student remarked, "Transforming plastic waste into art made me see how pervasive plastic is in our lives and the environment." Educators also noted the effectiveness of the hands-on approach in conveying complex ecological issues. The museum educator observed, "The hands-on experience allowed students to grasp the severity of marine pollution and think critically about their role in it." These reflections underscore the efficacy of participatory art in fostering environmental awareness and critical thinking among participants.

### *Student-led environmental initiatives*

The Bottled Ocean exhibition has influenced student-led environmental initiatives, translating educational experiences into tangible actions. Following their participation in the exhibition, several schools in the Wellington region introduced Plastic-Free Lunch Days as part of their sustainability efforts. Teachers collaborated with students to conduct waste audits, assessing the volume of single-use plastics present in lunch packaging. In response to their findings, students actively promoted the use of reusable

containers, beeswax wraps, and cloth snack bags, encouraging their families to adopt more sustainable alternatives. Additionally, they developed peer-led awareness campaigns, using data from their audits to highlight the impact of plastic waste on marine ecosystems. Reflecting on the initiative, a student said, "After joining the workshop in the museum, I wanted to do something about it. Now, my class has made an effort to stop using plastic bags in our lunchboxes." This direct application of exhibition concepts to everyday behaviors exemplifies how participatory engagement fosters environmental responsibility and empowers students to take meaningful action.

The *Bottled Ocean* exhibition also served as a catalyst for creative sustainability initiatives at a college in Porirua, where art teachers integrated George Nuku's methodology into their curricula. This approach led to the development of student-led recycled art projects, emphasizing the artistic and environmental potential of repurposed materials. As part of these initiatives, a group of students curated an exhibition featuring ocean-inspired sculptures crafted from discarded materials, reinforcing the concept that plastic waste can be transformed into meaningful artistic expressions rather than being viewed solely as refuse. Reflecting on the impact of this initiative, an art teacher observed, "Our students now see plastic waste not just as rubbish, but as a material that carries meaning. They are more conscious of what they discard and how they can creatively reuse it." These projects extended the core themes of *Bottled Ocean* beyond the museum, encouraging ongoing conversations about sustainability and creative problem-solving in schools.

### *Community-led clean-up campaigns*

Participation in *Bottled Ocean* also motivated students and community members to take direct environmental action through local clean-up initiatives. One notable example is the Petone Beach Clean-Up Crew, which organizes regular waste collection events along the shoreline. These initiatives involve systematically collecting, sorting, and documenting the types of plastic waste found on the beach, enabling participants to draw direct connections between their findings and the discussions from the exhibition on plastic accumulation in marine ecosystems.

The impact of these efforts extends beyond waste collection, fostering environmental awareness and personal engagement with sustainability issues. One participant reflected on the experience, stating, "When we were at the museum, we learned how plastic is everywhere in the ocean. Seeing it all over the beach made it real for us." This observation highlights the effectiveness of experiential learning, where hands-on participation reinforces the educational messages conveyed through art and science. These community-driven clean-up campaigns exemplify how participatory art exhibitions like Bottled Ocean can translate awareness into practical environmental action. By bridging artistic engagement with real-world ecological challenges, these initiatives empower individuals to take proactive roles in environmental stewardship, fostering both conservation efforts and a deeper, more personal connection to sustainability issues.

## *From engagement to advocacy: a lasting legacy*

Following the success of the *Bottled Ocean* exhibition, the Pātaka Art + Museum implemented several initiatives to enhance sustainability within its operations:

- Reducing Waste in Exhibition Design: Pātaka developed the "Sustainability—Reduce, Reuse and Recycle it!"[16] school program, which emphasizes the use of repurposed and biodegradable materials. This program encourages students to transform discarded items like plastic bottles, cereal boxes, and magazines into new art forms, promoting waste reduction and creative reuse.
- Integrating Sustainability into Educational Programming: The museum introduced the "Eco" Art program,[17] inspired by environmental artist Andy Goldsworthy. This initiative guides students to create ephemeral artworks using natural materials, fostering an appreciation for the environment and highlighting the transient beauty of nature.
- Strengthening Collaborations with Environmental Organizations: Pātaka hosted exhibitions like "The Greening of New Blueland"[18] by artist Elizabeth Thomson, which explored themes of marine pollution and climate change.

Through these initiatives, Pātaka Art + Museum has demonstrated a commitment to embedding sustainable practices within its operations and educational offerings, fostering long-term community engagement in environmental stewardship. As Nuku said: "The public involved then become themselves spokespeople for the messages and authorities of the meanings behind each element and the installation as a whole."

The *Bottled Ocean* exhibition illustrates how participatory art can serve as a powerful medium for scientific education, making complex environmental issues more accessible and engaging. By integrating artistic expression with ecological awareness, the exhibition fosters experiential learning that extends beyond traditional educational methods. The participatory nature of the project encourages long-term action, as evidenced by school-based programs and community clean-ups initiated in response to the exhibition's message. The museum's sustainability initiatives also demonstrate the transformative potential of art–science collaborations.

## Establishing and sustaining art–science partnerships in museums: challenges and strategies

Art–science collaborations in museums offer an innovative approach to engaging audiences with complex environmental and scientific issues. However, developing and sustaining these interdisciplinary initiatives requires careful planning, institutional support, and strategic partnerships. While projects like *Bottled Ocean* and *The Unseen* demonstrate the transformative potential of these collaborations, their success is contingent upon effective coordination between artists, scientists, educators, and museum professionals. This section explores key strategies for fostering art–science partnerships, addressing common challenges, and ensuring long-term impact.

### *Framework for successful art–science collaborations*

(1) Establishing Interdisciplinary Partnerships

The foundation of an effective art–science collaboration is a clear alignment between artistic and scientific objectives. To achieve this, museums must facilitate early and ongoing dialogue between all stakeholders, ensuring that:

- Scientists contribute empirical research while respecting artistic interpretation.
- Artists translate data into engaging and thought-provoking experiences without distorting scientific accuracy.
- Museum educators and school teachers bridge disciplinary knowledge, making concepts accessible to diverse audiences.

(2) Institutional and Financial Support

Long-term sustainability of art–science initiatives depends on strong institutional backing and diversified funding sources. Museums can:

- Secure research grants from scientific organizations and government agencies
- Partner with universities and conservation groups to access expertise and resources
- Engage corporate sponsors with sustainability interests while maintaining artistic and scientific integrity.

(3) Designing Engaging and Participatory Experiences

Successful art–science collaborations prioritize interactive engagement, allowing visitors to participate actively in knowledge creation. Effective strategies include:

- Workshops and hands-on activities
- Citizen science elements, where audiences contribute to real scientific research
- Multisensory and immersive installations, making abstract scientific concepts tangible.

### *Challenges in implementing art–science collaborations*

(1) Bridging Disciplinary Differences

One of the most significant challenges in art–science partnerships is navigating different methodologies and priorities. While scientists rely on empirical precision, artists often emphasize interpretation and abstraction. Misalignment in expectations can lead to:

- Disagreements over how data is represented in artistic work
- Tension between aesthetic choices and scientific accuracy
- Difficulty in communicating complex scientific ideas without oversimplification.

(2) Logistical and Material Constraints

Art–science projects often involve large-scale installations, unconventional materials, and technical complexities, requiring:

- Sustainable material sourcing to align with environmental themes
- Technical expertise in fabrication and conservation to ensure long-term durability
- Adaptability for traveling exhibitions, making installations accessible across different museum contexts.

(3) Sustaining Audience Engagement Beyond the Exhibition

A common pitfall in museum-based collaborations is short-lived engagement, where audience interaction ends with the exhibition. To ensure lasting impact, museums can:

- Integrate exhibition themes into long-term educational programs
- Leverage digital platforms to maintain community interaction
- Encourage real-world actions, such as conservation projects or policy discussions.

## Conclusion

The integration of art and science within museum spaces has proven to be a powerful method for engaging audiences in pressing environmental challenges. Through case studies such as *The Unseen* by Gabby O'Connor and *Bottled Ocean* 2116 by George Nuku, this study has demonstrated how participatory and interdisciplinary approaches foster deeper cognitive, emotional, and behavioral engagement with scientific issues. These projects illustrate that by merging artistic expression with empirical data, museums can create immersive learning experiences that make complex environmental issues more tangible and accessible.

Beyond the exhibition space, the long-term impact of these initiatives is evident in the student-led sustainability programs, community-driven clean-up efforts, and the integration of sustainability-focused curricula in schools. The success of these projects underscores the necessity of continued interdisciplinary collaboration and the strategic design of participatory experiences to maximize engagement. Moreover, the challenges inherent in art–science collaborations—such as disciplinary differences, logistical constraints, and sustaining audience involvement beyond the exhibition—highlight the need for carefully structured partnerships between artists, scientists, teachers, and museum professionals.

As museums continue to evolve into dynamic spaces for learning and activism, the role of art–science collaborations in fostering ecological awareness and collective action becomes increasingly significant. By embracing interdisciplinary strategies, museums can move beyond passive knowledge dissemination and instead empower communities to actively engage with environmental stewardship. In doing so, they not only enrich public understanding of scientific issues but also cultivate a generation equipped to navigate and address the complexities of a rapidly changing world.

## Notes

1. Macdonald and Silverstone, *Science on Display*, 69–87.
2. Hein, "Learning in the Museum," 15–27.
3. Falk and Dierking, "Learning from Museums," 99–110.
4. Hall, *Virtue Appreciation and Sustainability*, 3–7.

5. Kolodziejski, *What is Missing*, 428–445.
6. Szymanski et al., *Crossing Kingdoms*, 1–7.
7. Helmreich and Jones, *Science/art/culture*, 97–115.
8. MacFadden et al., Natural History Museum, 875–882.
9. Whānau is a Māori word. According to the Te Aka Māori Dictionary, whānau can function as both a verb and a noun. In this article, whānau is used as a noun, meaning extended family or family group.
10. The final exhibition of The Unseen took place at the Engine Room, Massey University's gallery in Wellington, in 2021. https://www.sciencelearn.org.nz/events/1659-the-unseen-final-exhibition
11. Thompson, *Lost at Sea*, 838.
12. Cox et al., *Human Consumption of Microplastics*, 7068–7074.
13. Schuyler et al., *Risk Analysis Reveals*, 567–576.
14. Rochman et al., *Ingested Plastic Transfers Hazardous Chemicals*, 1–7.
15. George Nuku: Bottled Ocean 2116 Interview at Pātaka Art + Museum. https://www.youtube.com/watch?v = 4-9UCq6E79I
16. Sustainability – Reduce, Reuse and Recycle it!: https://pataka.org.nz/learn/school-trip-programmes/Sustainability/
17. "Eco" Art program: https://pataka.org.nz/learn/school-trip-programmes/Eco-art/
18. The Greening of New Blueland: https://pataka.org.nz/whats-on/exhibitions/elizabeth-thomson-the-greening-of-new-blueland/

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## About the author

***Chang Xu*** completed her PhD at Toi Rauwhārangi College of Creative Arts, Massey University, Aotearoa, New Zealand. Her PhD research centered around fostering greater involvement of creative practitioners in children's museum and gallery education while promoting collaboration among various roles within art museums. Chang's passion lies in the realm of collaborative and interdisciplinary research, with a particular focus on the digital transformation and innovation within museum education.

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