GC Insights: Enhancing inclusive engagement with the geosciences through art-science collaborations

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Abstract. Art-science partnerships offer valuable opportunities to enhance inclusive engagement with research through collaborative creative practice. Here, we present two case studies of interdisciplinary approaches to contextualising environmental science for wider audiences. We synthesise lessons learned from these case studies and associated stakeholders to provide advice for conducting successful art-science collaborations that help to broaden interactions with environmental geoscience research.

1 Introduction

The adverse impacts of climate change and biodiversity loss are increasingly apparent, disproportionately affecting disadvantaged and socially vulnerable populations (Arkema et al., 2013). Now is consequently a timely opportunity for engaging wider audiences in environmental geoscience as public awareness of climate and biodiversity research has also intensified (Simis et al., 2016; Rossi et al., 2020; Lee, 2021). Art-science approaches offer an alternative to the traditional linear communication of research, providing a platform for participatory dialogue that may build trust in science outreach (Mach et al., 2021).

Art-science partnerships have become increasingly popular and can take many forms (Tooth et al., 2019), ranging from more conventional 'artist as the communicator' to truly collaborative initiatives whereby projects are co-conceived, conducted, and evaluated by cross-disciplinary participants. The latter supports knowledge co-production, whereby the concept of 'seeing double' (Mould et al., 2019) - through both an art and science lens - can help scientists to understand different perspectives and relations to their subject matter (Risner et al., 2019; Marlton and Robson, 2020). A recent Geoscience Communication Special Issue provided insight into the diversity of art-geoscience projects already occurring, demonstrating where geoscience and art have successfully collaborated to study topics such as climate change, geotourism, or cultural heritage (Lanza et al., 2020).

Art-geoscience projects may also capacitate audiences to 'experience' landscapes and geographic concepts they have not been exposed to (Gates, 2017). This has significant implications for inclusive outreach, as empowering viewers to (virtually or

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physically) interact with subjects allows for the individual interpretation of information, instead of acting as a recipient (Stewart and Lewis, 2017; Mould et al., 2019; Locritani et al., 2020). Emotional engagement with previously impalpable concepts is important in shifting public perceptions and responses to environmental change (Schneider and Simon, 2014; Lee, 2021).

Here, we share experience-based advice for conducting successful art-science collaborations that enabled wider public engagement within the environmental geosciences. Art is broadly defined to include many forms of creative expression, including painting, photography, film, poetry, and music (Tooth et al., 2016). We scoped environmental geoscience as the study of ecological and geophysical processes that influence our environment and the impacts of associated human activities. We provide two case studies of collaborative art-geoscience projects and the results of interviews with an artist, art-scientist, and an exhibition officer from these examples to synthesise experience-based recommendations for successful partnerships.

2 Methods

We sought to reveal enabling conditions for multi-stakeholder collaborations using an illustrative case study approach. The objective of this study was to evaluate two retrospective case studies through a series of semi-structured interviews for in-depth analysis of factors contributing to successful art-science partnerships (Thomas, 2011). The case study examples were selected from our networks for their collaborative nature and outreach activities. Representatives from the case studies were invited for interview to represent three common stakeholder groups in art-science partnership: an artist, scientist, and an exhibition officer. We conducted semi-structured interviews with the case study representatives using a set of preliminary questions which were pilot tested with two researchers in the team (Kallio et al., 2016). Interview results were thematically analysed and categorised according to establishing, conducting, and post-partnership stages. The results were summarised into key recommendations for building art-science partnerships, alongside contextual information on aims and motivations for partaking (Supplementary Material). The synthesis was iteratively co-developed with each stakeholder's team to ensure findings reflected a collective opinion.

Case study 1 – Connecting biodiversity and immersive art

An art-science exhibition hosted at the Oxford University Museum of Natural History titled 'Biodiversity' featured work by contemporary artist and environmentalist, Kurt Jackson (https://www.kurtjackson.com/about/). This exhibition displayed Jackson's artworks amongst the Museum's collections, showcasing interlinkages between art, science, and natural history. Selected works were accompanied by responses from Oxford University scientists to highlight connections with research and encourage viewers to consider what biodiversity means to them. Figure 1 features 'Taxonomy of a Cornish Foreshore' and the researcher's response as displayed in the exhibition. Integrating artwork with museum specimens and contemporary research created a unique environment in which visitors could connect with the natural world in their immediate environment whilst positively engaging with research that tackles the wider biodiversity crisis.

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Art-science collaborations therefore help to bridge disciplines and facilitate multi-contributor dialogue, which is necessary to address complex environmental challenges.

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Case study 2 – Coupling art and climate negotiations

In order to share outcomes of the recent COP26 climate negotiations (https://ukcop26.org/) in a more accessible and memorable format, artist and scientist Dr Cécile Girardin collaborated with mural painter Lisa Curtis and youth activist Arnaud Girardin-Potts to create a 4m-long mural within the COP26 negotiation zone (Fig.S2, Supplementary Material). The piece was intended to build bridges between the many activists and civil society representatives demonstrating in Glasgow and globally, and the thousands of negotiators debating within the conference centre. This mural captured the main takeaways of COP26, deploying a digestible combination of vibrant colours, shapes, and pithy statements. The dynamism of the artwork invites viewers to interpret the interconnectedness of nature, climate, and society, explore the complexities of the climate negotiations, and alludes to key debates that shaped COP26 talks.

3 Results

These findings summarise key lessons learned from interviews with each stakeholder directly involved in the case studies above, specifically relating to the establishment and fulfilment of art-science partnerships for inclusive engagement. The interview participants (art-scientist, artist, exhibition officer) each reported communicating to wider audiences as a primary motivation for partaking in these collaborations. To achieve this, interviewees highlighted the benefits of engaging other disciplines to connect multiple viewpoints, in addition to considering the contexts in which an art-science partnership is shared. For example, according to the exhibitions officer, the Museum of Natural History setting for Case Study 1 attracted new audiences "who may be engaged with the arts but less likely to visit a science museum, by offering different perspectives on natural history." Regarding Case Study 2, the art-scientist reported that creating a mural during COP26 conference proceedings facilitated a piece that reflected the complexities of climate negotiations, as this allowed for dynamic incorporation of key debates and diverse perspectives in real time.

In terms of establishing art-science partnerships, interviewees recommended developing strong relationships between project stakeholders for collaborations that are founded on trust and respect. The artist from Case Study 1 highlighted the necessity of being well informed by those active in the relevant scientific field, as "[o]nly then can an artist facilitate the understanding of the environment. For the final work to have any profundity or agency the creativity needs to be underpinned by genuine research and knowledge." The art-scientist interviewee from Case Study 2 similarly emphasised the importance of communicating research in digestible ways without oversimplifying the science, finding that "[s]ynthesising complex concepts into illustrations" helped to communicate their research better and to wider audiences. Further, strong partnerships accommodate for honest dialogue and consequently support the critical process of collectively evaluating and adapting art-science projects. The exhibitions officer from Case Study 1 evidenced how impact should be monitored with specific metrics that evaluate both the process of collaboration and the short- and long-term impacts of an inclusive engagement project,

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Moved up [2]: Science communication efforts have traditionally focused on the linear communication of facts (Simis et al., 2016). Otherwise known as the 'deficit model', this assumes that knowledge gaps between scientists and public understanding result from a lack of information, resolved by one-way communication efforts. However, this approach oversimplifies relationships between knowledge, beliefs, and behaviours (Suldovsky, 2017). The deficit model may not account for audiences whose experiences and conceptions of science are often different to those of an 'expert', trained to process information objectively (Simis et al., 2016). There is a need for science communication to transition from lecturing 'matters of fact' to co-developing narratives for 'matters of concern' (Stewart and Lewis, 2017).

Moved up [1]: Art can be a medium through which individuals connect with otherwise abstract social and ecological changes, in a manner that is engaging and without trivialising the content (Locritani et al., 2020). Art-science may therefore be a powerful tool for building trust in otherwise intangible scientific concepts and spurring discourse around socially relevant environmental science (Mach et al., 2021).

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contributing further to the evidence base on conducting art-science partnerships. A table of further recommendations along with additional data on the aims and motivations for collaborating can be found in Supplementary Material.

4 Discussion and Conclusions

This work presented two case studies of interdisciplinary partnerships for wider engagement in the environmental geosciences. These examples demonstrated different approaches to facilitating knowledge exchange with communication tools co-developed through art-science partnerships. The stakeholder interviews corroborated that art-science collaborations can provide a platform for knowledge co-production, with each representative emphasising the value of cross-disciplinary partnerships for encouraging self-reflection and interacting with new viewpoints. The importance of mutual trust and respect in building these relationships has been reflected in other art-geoscience collaborations (Risner et al., 2019), allowing for the greater appreciation of other disciplines (Marlton and Robson, 2020). Significantly, interviews with the artist and art-scientist revealed cautions against the oversimplification of science for communication purposes, emphasising the importance of taking time to foster collaborations based on a genuine understanding of the research, similarly highlighted by Locritani et al. (2020).

Our research activity revealed that each stakeholder representative was predominantly motivated by a common goal of engaging new audiences, a finding reported in a previous survey of participants in art-geoscience partnerships (Archer, 2020). An interesting result of the interview with the exhibitions officer is the opportunity to situate art-science partnerships in varied contexts to enhance inclusive engagement, such as the Museum of Natural History exhibition, Case Study 1. By situating the exhibition amongst museum specimens, the art-science project connected visitors to both contemporary research and multiple perspectives on natural history. Visitors reported feeling predominantly inspired by the exhibition, commenting on how the artist made "the everyday and ordinary seem so extraordinary", and provoked attendees to reflect on concepts of biodiversity and habitat loss. As explored by Van Loon et al. (2020), combining artistic practice with conventional methods for building resilience to natural hazards may provide a more holistic understanding of social as well as ecological risks, leading to more comprehensive preparation for natural disasters (Van Loon et al., 2020). In responding to Kurt Jackson's work, the researchers in Case Study 2 were encouraged to situate their science and explain the social relevance. Such knowledge exchange is an asset in the development of effective solutions to the climate and biodiversity crises we are facing. In Case Study 2, the art-scientist was able to co-create the mural with perspectives of those attending and speaking at the COP26 conference and found this to be a widely accessible and engaging format. This co-development of science communication is pertinent to publicly contested and politicised matters, such as biodiversity loss and climate change (Suldovsky, 2017).

In conclusion, enhancing inclusive engagement within the geosciences can be achieved through art-science partnerships. Our findings suggest that enabling conditions are important to create safe spaces for the knowledge exchange and reflective practice. Starting with relationship building based on mutual respect was found to support the successful development of equitable partnerships and co-production of ideas. Further, our case studies underscored that considering different contexts for

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Moved up [3]: **3.2 Case study 1 – Connecting biodiversity and immersive art**¶
An art-science exhibition hosted at the Oxford University Museum of Natural History titled 'Biodiversity' featured work by contemporary artist and environmentalist, Kurt Jackson (https://www.kurtjackson.com/about/). Jackson aims to broaden his audience's experience of nature, encouraging viewers to consider how ecosystems are changing due to climate change and human impacts through expansive mixed-media works. As he explains, "*by being aware of the life with which we share this planet we can first appreciate it, then learn to conserve it*". Though his tools and methods may differ, Jackson's intentions as an artist are greatly similar to those of a biodiversity scientist; his immersive approach to painting allows him to document and acknowledge the complexity and fragility of the natural world. This exhibition displayed Kurt Jackson's artworks amongst the Museum's collections, showcasing the interlinkages between art, science, and natural history. Selected works were accompanied by responses from Oxford University scientists to highlight connections with research and encourage viewers to consider what biodiversity means to them. An example can be seen in Fig.1, featuring 'Taxonomy of a Cornish Foreshore'

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Here, we explored the potential benefits of art-science collaborations in the geosciences. We highlighted how sharing knowledge through the universal language of art helps to bridge backgrounds and knowledge systems.

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Stepping outside disciplines to situate data within wider contexts can therefore increase research impact. The art-science approach consequently provides a platform for reflection and knowledge exchange (Risner et al., 2019). As explored by Van Loon et a ... [25]

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sharing art-science partnerships (e.g., a museum) can contribute to the success of inclusive engagement initiatives. This work explored two case studies in which the team had been involved; the next step would be to increase the number of interviews with a wider group of stakeholders from a diverse range of case studies. These results are experience-based suggestions for practising a successful art-science partnership and represent a preliminary example of the value of investigating enabling conditions of interdisciplinary collaborations for inclusive knowledge exchange.

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Author contributions

RW conceived the article and led the writing process, supported by LW. KJ and NS designed and ran the exhibition. CG designed and co-created the COP26 piece. All authors contributed to the development of the understanding and ideas presented.

Competing interests

The authors declare that they have no conflict of interest.

Financial support

The work was supported by the University of Oxford, ESRC IAA Knowledge Exchange Dialogues Award.

Acknowledgements

We thank Poppy Menzies Walker for her encouragement and sage advice on this paper.

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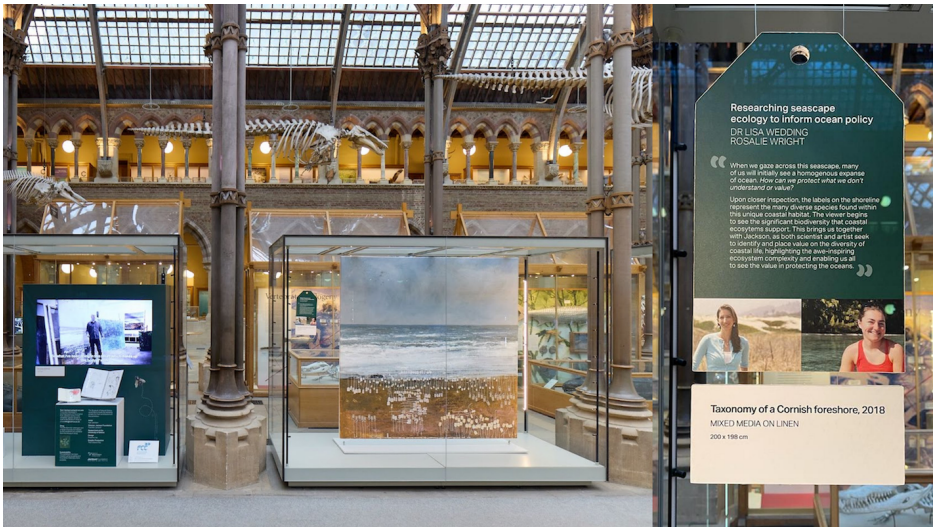

Figure 1: 'Taxonomy of a Cornish Foreshore' by Kurt Jackson, on display as part of the Biodiversity exhibition at the Oxford University Museum of Natural History. The piece shows how the beach, the foreshore, has a particular resonance to many whilst also being a biodiversity hotspot, a liminal zone and the meeting point for ecosystems. As Jackson explains, "*a coastline is the front line where our impact is tangible and alarmingly visible - if we allow ourselves a moment we can see and be aware of the fragility, diversity and complexity of this world, but crucially also the beauty*". This work was on display featuring the following response from authors Rosalie Wright and Dr Lisa Wedding: "*When we gaze across this seascape, many of us will initially see a homogenous expanse of ocean. How can we protect what we don't understand or value? Upon closer inspection, the labels on the shoreline represent the many diverse species found within this unique coastal habitat. The viewer begins to see the significant biodiversity that coastal habitats support. This brings us together, as both scientist and artist seeking to identify and place value on the diversity of coastal life, highlighting the awe-inspiring ecosystem complexity and enabling us all to see the value in protecting the oceans."* (Image credit: Museum of Natural History by Ian Wallman, pixieset.com)

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Reviewer 2: The research aim of the article is not su#ciently well-stated to prepare readers to comprehend the manuscript. At times it appears that the authors wish to demonstrate the e#cacy of art-science collaborations in co-creating knowledge and/or communicating important geoscience concepts to nontradiational audiences. At others, it seems they want to identify recommendations on how to enable successful collaborations between stakeholders in art-science collaborations (artists, scientists, exhibition sta$). It is my opinion that the work cannot achieve the former, but may be able to demonstrate examples of the latter, though they will not be exhaustive due to the limited scope of the study. This should be much clearer in the abstract, introduction, and conclusions.

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Response: We have adjusted the abstract, introduction and conclusions to specify that our research aim was to provide reflections and recommendations on successful partnerships. We have revised text accordingly throughout the article to clarify this.

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Reviewer 2: The methods employed, as written, are rather unclear in the article. The fact that all results are drawn from just two case study projects only becomes apparent near the end of the manuscript. Exactly what the authors were looking to extract from their literature review and interview question development isn't stated - there are many vagueties such as simply stating "learning outcomes" and "information". How the interview data was processed to arrive at themes and conclusions is stated nowhere in the manuscript.

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Section 2: Overall this section is unclear, but also repetitive in many aspects. It could do with rewriting with a clear focus. Examples of unclear aspects are

- What you were looking to "nd in literature review?
- How many people were identi"ed to interview? What was the makeup? What was the criteria in identifying?
- Who the "outcomes and impact" are meant to be on? If the stakeholders interviewed and their partners then that would be appropriate, however, if this is meant to concern the attendees then I do not agree that the study can adequately assess these.

Page 2: [17] Commented [RW10R8] **Rosalie Wright** **19/01/2023 15:28:00**

Response: The methods have been re-written to specific the number of case studies and interviewees, the criteria for interviewee selection, and we have specified our key intentions. As requested, we have further clarified our methods and reasoning.

Page 2: [18] Deleted **Rosalie Wright** **16/01/2023 19:31:00**

Page 2: [19] Deleted **Rosalie Wright** **26/12/2022 11:51:00**

Page 2: [20] Deleted **Rosalie Wright** **26/12/2022 11:53:00**

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Reviewer 2: . Case studies: These should be stated outright before any results are presented, so it provides much needed context to what the interview data is in relation to - their experiences of undertaking these two projects.

Page 2: [23] Deleted **Rosalie Wright** **26/12/2022 16:31:00**

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Page 4: [25] Deleted **Rosalie Wright** **27/12/2022 11:21:00**