Creative Partnerships and Cultural Organisations: "Enabling" and "Situating" Arts–Science Collaboration and Collective Learning

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Abstract Arts–science activities are proliferating globally, whilst demonstrating significant capacity to shift public thinking (and potentially action) in new ways that confront many of the pertinent challenges of our times, such as sustainability. Transdisciplinary arts–science practices offer enhanced possibilities to increase this agency. However, this can only be assured through the development of supportive institutional material and social infrastructures. In this chapter, we explore how to best *enable* and *situate* such projects, drawing upon the work and practices of transdisciplinary media artist Keith Armstrong. By comparing two Australian cultural organisations he has worked with (a university gallery and a public arts organisation), we analyse how institutional frameworks can better support such projects and programs, mitigated by the site and location of the work. We then ask, what is the future of this mode of activated practice and how might we best foster it?

Keywords: Transdisciplinary practice; public engagement; arts–science; organisational frameworks; creative collaboration.

Arts–Science Partnerships and the Significance of Contemporary Collaboration Across Disciplines

Cooperation between scientists and artists has been developing steadily over the last 15-20 years, with both smaller groups and teams working in dynamic creative partnerships that have moved thinking and practice between and across disciplines. This collaborative activity is occurring in diverse environments including tertiary institutions; via residency programs in science research centres; in private and public galleries in the form of new commissioned works; in curated exhibitions and public programming; and discursively at international conferences and symposia.[1] This suggests an increasing focus upon the underlying conceptual similarities that the arts and sciences share (Wilson 2014) and a growing interest and commitment to the potential of inter- and transdisciplinary

[1] Support for transdisciplinary education has increased within tertiary institutions, albeit slowly e.g. SymbioticA, the Centre of Excellence in Biological Arts at the University of Western Australia, University of Washington DXARTS program, Masters programs at Central St Martin's School of Art in London, Cardiff University's School of Art and Design and Rhode Island School of Design (See: www.expspace.risd.edu). The 2017 International Symposium on Electronic Arts (ISEA) panel: *Training Methods for Transdisciplinary Collaboration: Best Practices and Didactics for Team Work* is a recent example of discursive activity (See: www.isea2017.isea-international.org).

approaches in developing the skills and knowledges to engage seemingly intractable problems of the 21st century (Malina, Strohecker and LaFayette 2015). In this emerging form of 'boundary work' (Klein 2010), disciplinary differences are seen as strengths, with practitioners each having something to learn from the other, and projects taking on the character of participating disciplines in ways that actively blur the lines between them.[2]

Science has become a focal point for many artists, in part because science production and its dissemination are undeniably social practices with significant public interest and import (Gabrys and Yusoff 2012). Artists often actively seek out research partnerships within scientific communities in ways that go far beyond reflecting science-inspired motifs or concepts, and are now found working in hospital clinics, at dissecting tables, in neuro-imaging laboratories or meteorological centres (Wilson, Hawkins and Sim 2014; Wilson 2017). The affective dimension of the arts (beyond illustration, instrumentalism or activism), and the potential of creative practitioners to contribute to problem solving in transdisciplinary partnerships is also being understood with greater clarity and nuance. Likewise, scientists are coming to appreciate the value of building rich working relationships with artists beyond that of routine scientific illustration (Ox and Lowenberg 2013; Wilson 2017). Many scientists have become compelled to expand their methods for producing science by working beyond their disciplinary boundaries, and in the process have discovered new ways to engage with publics.

The ability to engage diverse publics, and the potential to 'do' social, cultural and political work are important aspects of collaborative arts–science practice (Gibbs 2014). For example, researchers and practitioners concerned with environmental pressures and the challenge of sustainability have demonstrated how arts–science discourses can provide new opportunities for reconsidering the role of cultural and creative activity in relation to environmental change (Bennett 2012). Because the contemporary dilemma of climate change is complex and multidimensional there is a need to respond with emergent and pioneering forms of practice (Gabrys and Yusoff 2012). New creative projects and exhibition spaces have the potential to reframe partisan political debate, and they can also bring the material thinking of artists and scientists together in ways that encourage audiences to reflect on both practices more deeply (Leimbach 2015).

Major funding bodies in the USA, UK and Australia have encouraged such collaborative activity across the arts and sciences in recent times.[3] The Sciart grant scheme of the Wellcome Trust (the UK's leading biomedical charity) ran between 1996 and 2005, giving its name to a whole area of activity. Over this period the program fostered hundreds of new collaborations between artists and scientists and helped remove

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[2] The shift from inter- to transdiciplinarity introduces multiple layers of complexity with the necessity to include multiple stakeholders in the process of research design and problem solving (for example industry and multiple publics).

[3] High-level support includes the Australian Network for Art + Technology Synapse program and the National Science Foundation (NSF), the National Endowment for the Arts (NEA) and the National Endowment for the Humanities (NEH) in the USA. Likewise Arts and Humanities Research Council England Art and Science Research Fellowships encouraged experimentation and progress in collaborative partnerships and recently RCUK, (which oversees the seven separate UK research funding councils), has committed to significant cross-council funding for a broader and more systematic investigation of knowledge structures than was possible under the earlier generation of art-science schemes.

many barriers to cross-disciplinary collaboration. The funding also catalysed new types of relationships between arts promoters, arts venues, colleagues and peers, and with public and professional audiences (Glinkowski and Bambford 2009). In the USA, the ArtScience movement championed by the *Leonardo* publishing group and the International Society for the Arts Science and Technology (ISAST) is similarly important.

The SEAD network (Scientists, Engineers, Artists, Designers) established in 2011 represents a broad cross-section of individuals and institutions interested in transdisciplinary collaborative practice (See: www.xsead.cmu.edu), focusing on four advocacy areas: culture/economic development, research/creative work, learning/education and collaboration/partnership, addressing challenges for teamwork in different academic and professional cultures. The terms "enabling" and "situating" in this chapter's title reference the eleven "Action Clusters" in *Steps to an Ecology of Networked Knowledge and Innovation: Enabling New Forms of Collaboration among Sciences, Engineering, Arts, and Design* (Malina, Strohecker and LaFayette 2015). This document draws together findings from dozens of international White Papers examining the feasibility of transdisciplinary collaboration. The authors suggest that addressing these "actions" will help in the facilitation of new practices, and frame questions stakeholders may use as entry points for sustained research, consideration and intervention.[4]

Creating Balanced Relationships and Supportive Environments for Transdisciplinary Arts–Science Partnerships

In this section we examine some of the challenges and opportunities for arts–science partnerships noted by SEAD (Malina, Strohecker and LaFayette 2015) and the broader literature, notably sustaining balanced relationships in hybrid practices, and the creative environments that foster and support transdisciplinary practices, back-grounded by our own case-based research.

Enabling Collaborative Arts–Science Practice: Challenges and Opportunities

There are points of conflict common to many inter- and transdisciplinary practices. The literature details obstacles resulting from sociological *asymmetries* such as differing personal and institutional environments, incompatible expectations due to dissimilar organisational and commercial pressures, and conflicting funding arrangements (Kemp 2011; Hawkins and Wilson 2014; Malina, Strohecker and LaFayette 2015).[5] Promotion and tenure in universities may also increase resistance to new forms of practice, as do different economic realities faced by individuals from different professional backgrounds.

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[4] The SEAD 11 Action Clusters and Key Processes are (1) Translating: Problem-driven connections among academic, commercial and civil societies (2) Convening: Overcoming transdisciplinary thresholds (3) Enabling: Sustaining balanced SEAD relationships (4) Including: Spurring innovation through diversity (5) Embedding: Public engagement and negotiation (6) Situating: An emerging ecology of creative places (7) Sense-making: Multimodal knowledge and ways of knowing (8) Documenting: Recording and transmitting (9) Learning: Tapping into the passion and creativity of lifelong curiosity (10) Collaborating: Methodologies working across disciplines and institutions (11) Thriving: SEAD ingredients as essential contributors to healthy communities.

[5] This is particularly true of teams working across disciplines in transdisciplinary ways, and with disciplines that do not traditionally mix (for example engineering, humanities and design).

SEAD also report many more artists-in-residence programs in science institutions than scientists-in-residence programs in arts, design and humanities programs (Malina, Strohecker and LaFayette 2015).

Long-standing assumptions also need acknowledgement to enable productive outcomes e.g. examining notions of 'truth' and knowledge creation and resolving whether there can be compatible forms of these across widely divergent areas of human experience and endeavour (Wilson et al. 2014). Collaborators must therefore develop shared languages and define what shared success might look like, committing to ongoing learning that builds trust and ensures quality of results in terms of both depth and breadth. Even finding a mode of collaboration can be complicated due to divergent views of what collaboration actually means. Artists may encounter contexts of consultation and information gathering, rather than equal exchange. Artist Susan Aldworth's suggests her work with scientists is not a 'true collaboration. It is an altogether different, though significant, association […] it is more a sharing of knowledge and opportunities, and represents a long-overdue leap into each other's worlds' (Aldworth and Ingham 2017, p. 182). However, artist Luke Jerrams argues that creative projects certainly have the potential to raise the profile of scientific research - not an expectation that many scientists have when they agree to participate. Jerrams' projects have high, measurable impact with publications in well-established journals including *Nature* and *The Lancet,* extensive media attention and exhibition audiences of tens of thousands (Hawkins 2014).

Situating Collaborative Arts–Science Practice: Challenges and Opportunities

Cultural sites can mediate and broker new knowledge and provide compatible places for meeting, making and learning. While tailor-made spaces are vital, pre-existing galleries, museums and other independent cultural organisations may provide space for collaboration and for diverse publics to be exposed to arts–science projects if they can shift or expand their mandate. As Subramaniam (2013) asks, 'how might we use galleries as spaces with which to think, as performative sites for transformation, rather than as venues for display?' Critical reflection on the identity and function of cultural organisations and the ordering strategies at work within them is essential, given that many institutions still separate objects, artworks and displays along disciplinary and epistemological lines. Inter-, cross- and transdisciplinary research and curating has already begun to significantly influence museum and gallery practices and methods. For example, London's GV Art gallery has become a leading private art/science institution, commissioning new works, establishing collaborative partnerships and hosting lively debates in virtual and physical forums. The ArtScience museum in Singapore, the Science Gallery Dublin and the Institute for Figuring in Los Angeles similarly operate outside of familiar institutional frameworks, acting as places for learning and becoming the 'pedagogical anomalies' (Ellsworth 2005) crucial for producing and presenting transdisciplinary practice.

The Leonardo-fostered ArtScience Manifesto notes that new forms of practice may also necessitate that art moves entirely away from galleries and museums into newly invented physical and virtual spaces and places (Root-Bernstein et al. 2011), better suited to engagement in building communities of interest and enquiry that foster communication and strengthen networks (Hawkins and Wilson 2014). MIT's Media Lab, La Laboratoire

in Paris, Symbiotica in Perth, and Harvard University's Initiative for Innovative Computing (IIC) are examples.

Creative Partnerships and Cultural Sites in Australia: Two Sites / Two Projects

We now examine in context two recent projects to understand how their very different sites facilitate new/different forms of collective learning and engagement. Our data analysis weaves these findings into broader issues of enabling and situating arts–science collaborations. Data was gathered from both sites via field notes, interviews and participant observation, informed by ethnographic research methods. Contributors include the artist and other disciplinary experts, practitioners, the visiting public, students, teachers, gallery curators and staff.

Dr Keith Armstrong is the lead artist and initiator of both projects: *Black Nectar* for the *SiteWorks* program at Bundanon Trust (a rural public arts organisation in central NSW, Australia) and *Over Many Horizons* at UTS Art (a university gallery situated in inner Sydney, Australia). Both projects were developed with the input of scientists and other creative collaborators and are concerned with questions of ecology and sustainability. Armstrong's broad practice of 'embodied media' explores the use of sensory media, specialising in hybrid works with an emphasis on innovative performance forms, site-specific electronic arts, networked interactive installations, public arts practices and arts–science collaborations (See: www.embodiedmedia.com). His 23-year practice is foregrounded by a long-standing interest in scientific ecology, focused by the broad conceptual territory of ecological philosophy, particularly Deep Ecology and its related concept of Ecosphy (which originated in the 1970s in response to the emergent discipline of scientific ecology). He uses 'ecosophical' principles to establish starting and iterative reference points for investigations, thereby framing the desired transformational potential of such events.

(1) The Context: SiteWorks (Bundanon Trust)

Bundanon Trust is a multi-stranded arts organisation facilitating creation and presentation of arts, education and research, also increasingly modelling land restoration and environmental custodianship practices (See: www.bundanon.com.au). Their annual arts–science event *SiteWorks* invites participants' stay in residence, responding to the site through the lens of their specific discipline and through inter- and transdisciplinary collaborations. Artworks and performances, creative laboratories and collaborations emerge between scientists, artists, local residents and other disciplinary specialists onsite. New projects are shared with the public, in the spirit of an open and ongoing conversation. Collaboration is designed to invite practitioners from different disciplinary backgrounds to 'plunge' into the river together rather than build bridges over the (metaphorical) divide between disciplines (Head 2011; Leimbach 2015).[6] The annual *SiteWorks* events have grown larger and more audience-centric, focusing around particular themes, such as

[6] Another significant arts-science collaboration at Bundanon Trust has been the three-year ARC funded project, 'Portrait of the Shoalhaven River' involving scientists, artists and humanities scholars with the aim to 'increase understanding of both the region's natural environment […] and its cultural history' (See: www.bundanon.com.au/research-and-projects/shoalhaven-portraits/).

future of food, biodiversity and astronomy. The strategies that inform *SiteWorks* reflect the internal logic of a cultural organisation exploring how to creatively engage with larger global concerns in a place-based way, as described by an employee:

> You've got to be engaged with what's around you, and we know that the very local has all the features of the global. So there is no harm at all in engaging with the extremely local and I mean celebrating it and so much really significant contemporary art does that […] It's why with *SiteWorks,* we said that it's got to come out of this property, but people talk about the enormous issues, through the platform of the property (BT Interview).

(1) The Project: Black Nectar[7]

In 2014 the event embraced the theme of biodiversity, in a 'practical sense with a 24-hour Bioblitz, artistically with site-specific works and theoretically with discussions about earth law, science and art' (BT promotional material). Armstrong was invited to participate proposing a new work, *Black Nectar,* arising from ongoing collaborations between himself and Dr Peggy Eby (an Australian behavioural ecologist specialising in flying fox research), with key contributions from sound artist Laurence English, ecological scientist Heidi Millington and Luke Lickfold. The final work became a site-specific light & sound installation that invited audiences to take slow, sensory walks through the darkness of Bundanon's forest at night, augmented by numerous subtle audio and light interventions. In addition, Eby gave public talks and led field walks over the weekend to illuminate the ecological systems that support the flying foxes and their migratory pattern, whilst highlighting the threats to their existence.

Fig. 14.1 *Black Nectar,* LED and fibre optic panorama, Bundanon SiteWorks, 2014 (Image: Sam James, Courtesy of Bundanon Trust)

[7] The *Black Nectar* collaboration was assisted by the Australian Government through the Australia Council, its arts funding and advisory body, QUT Creative Industries and the Bundanon Residency Program.

During their collaboration Eby introduced the artist to her large biological dataset, in which she mapped the movements and concentrations of flying foxes. Grey Headed Flying Foxes are highly mobile mammals that travel seasonally between dispersed and now heavily fragmented forest habitats. They are significant forest pollinating agents and therefore crucial actors within any broad scale conservation program (Eby and Lunney 2002). By plotting the data across the seasons, Eby is able to understand how flowering events in differing bioregions often occur at irregular intervals and directly affect the presence of smaller or larger transient groups of these mammals at geographically dispersed sites. As the *SiteWorks* region fell within Eby's data set, she was able to drill down into it and predict the local vegetation types in advance, and thus the likely occurrence of flying foxes and other species at certain times of the year. The team ascertained that for a short, sweet period, Bundanon would become the place of 'Black Nectar', with these nocturnal animals arriving en masse to sup the nectar pulses as they swept across this part of eastern Australia.

In developing the project, participating sound artist Lawrence English and Armstrong chose to construct the bulk of their audiovisual work in a natural amphitheatre/forest clearing onsite favoured by Eby for its rich vegetation. Reflecting on the potential of the project to engage audiences, Eby indicated:

> The project deeply intrigues me. I am attracted by the possibilities to enhance human experiences of and responses to the natural world and by the examination of the cultural basis for environmental thinking. I'm drawn to the opportunity to explore fresh ways to communicate the research that has captivated me for many years, and I sense a potential for the development process and the work itself to enhance my research by revealing to me (as well as to the public) new ways to perceive nocturnal environments and seasonal systems (BT Interviews).

Fig. 14.2 *Black Nectar,* fibre optic lit form, Bundanon SiteWorks, 2014 (Image: Heidrun Lohr, Courtesy of Bundanon Trust)

Audiences took a 45-minute torch-lit walk from the festival site up into the forest alive with the early spring sounds of nocturnal insects, night mammals and birds. They then stopped for 15-minutes in the amphitheatre's almost total darkness which was augmented by ultra-low level, diffused points, strips and organic patterns of faint white led light, set at various distances and heights from the path, and with differing periods of on/off illumination, neither dominating or overrunning the already rich quality of the site. Soundscapes were delivered simultaneously, via small pairs of speakers, arranged throughout the bush in locations sympathetic to existing sounds, making full use of reflective boulders and cliff faces, enhancing the already lively atmosphere of the pitch black amphitheatre at the furthest point of the walk. Bundanon Trust Director Deborah Ely described the mood surrounding the event and its impact:

> As we climbed to the rock amphitheatre in near silence, lit by pin light torches, the excitement was palpable. […] No one wanted to leave. It felt like a unique adventure, an encounter with an unknown presence. Real immersion in the bush, through solitary expeditions, sensory walks or similar, are rarely experienced by most people. Being present in the bush at night is even more rare. The artwork suggested that the opportunity to experience the night is something we ignore – that there is a world available to us that we could inhabit if only we were open to it (BT Interviews).

The combination of subtle stimuli and a moonless night encouraged audiences to pause frequently and engage in deeply embodied listening. The sense of uncertain distances created by the lights, and hard to pinpoint sounds seemingly drawn from other places and times, further encouraged reflection upon connections between this place and other unseen, unknowable, distant locations.

(2) The Context: UTS Art

UTS Art has a strong external reputation as a contemporary art space, with a focus on innovative and research-driven exhibitions (See: www.art.uts.edu.au). The university is committed to research that impacts and benefits society, industry and the environment. There are no formal processes in place to assist the gallery in the building of collaborative creative inter- or transdisciplinary partnerships and research networks across faculty, so the process they use is organic and informal, relying upon gallery and academic staff to broker connections. Whilst there are also no formal expectations for gallery staff to engage with other faculty when developing exhibitions, public programs and education, the gallery needs to reach their internal audience (both staff and students) so engagement opportunities are actively pursued by gallery staff (UTS Art Interviews).

(2) The Project: Over Many Horizons (O|M|H)

The broader aims of the O|M|H program was to trial innovative approaches to understanding science and social contexts, to develop conversations across disciplinary divides, and use the visual and experiential tools of arts practice to communicate complex ideas about the environment and its cultural dimensions. Several months prior to the show Armstrong introduced the collaborative aims of O|M|H, seeking introductions across the university by gallery staff. He toured the Science facilities with artist in residence Lisa Roberts, was hosted off-campus on research excursions, and engaged with other specialists across UTS faculty.

Fig. 14.3 Keith Armstrong, *Over Many Horizons,* UTS Art, Sydney, 2016 (Image: Denis Beaubois)

Over Many Horizons (O|M|H) became an interactive, experiential 'whole of gallery' exhibition which showcased and extended two decades of Armstrong's ecologically engaged (ecosophical) practice and trialled new possibilities to extend his transdisciplinary interests. Key works from the artist's oeuvre were combined with new research practice from the local university context. Visitors encountered robotically controlled kinetic light works, telescopic tunnels of ethereal imagery and sound, and gently pulsing, ambiguous surfaces (UTS Art). They also had the opportunity to participate in hands-on robotics and electronics workshops, imaginative engagements with ecological science, and public conversations that explored questions central to the artist's ecosophical practice: *Why is today's environmental crisis a crisis of 'us', and how must we respond?*

Produced in collaboration with gallery staff and academics across the university, the public programming for O|M|H (called *Art for Complex Times*) coincided with National Science Week and Sydney Design Week, challenging diverse audiences to make their own connections between science, art, design, sustainability and social reality. One public event brought together a marine biologist, a political theorist, and a new media artist to discuss ecology as both science and metaphor in the acknowledgement that the issue of language and meaning across disciplines is a deeply complex challenge for collaborators. The marine biologist detailed the exacting science of ecology, describing the reluctance of most scientists to step outside the boundaries of the scientific method, and the common scepticism felt amongst scientists toward the use of ecology as a metaphor in other fields. The political theorist disrupted singular visions of ecology

arguing that ecology and the economy have clear links and that economics has drawn heavily from the natural sciences throughout its developments as a discipline in ways that are deeply and problematically metaphoric. The artist brought another dimension to the discussion by exploring philosophical ecologies and the work of philosophers like Timothy Morton who offer profound new understandings of humanity based upon ecological frameworks.[8]

Fig. 14.4 *Over Many Horizons*, UTS Art, Sydney, 2016 (Image: David Lawrey, courtesy of UTS Art)

Such public dialogue between 'expert' and 'non-expert' was central to the aims of the project. Reflecting on the underlying logic of his process, Armstrong indicates:

> Over Many Horizons is better understood as a network that brings together a community of concern and the desire to understand how to engage new forms of understanding and the celebration of possibility in a non-didactic, inclusive way. This writing is as much part of that as was the exhibition or days out diving with Prof. Bill Gladstone and Lisa Roberts on Sydney harbour (UTS Art Interviews).

[8] Timothy Morton's *The Ecological Thought* questions the very nature of ecologies, ascribing them as entangling "meshes", free of any one central position that might privilege any form of being or understanding over another, interlinking everything with infinite complexity such that things can only be perceived in relationship to other things - as deeply entangled, interwoven, delicate, dense, multimodal, multi-dimensional - and therefore ultimately complex and beyond concept or thinking.

Armstrong envisions O|M|H as an ongoing project that will evolve as new collaborators engage in different ways with contemporary ecological dilemmas in new contexts, continuing to bring scientists, artists, academics and publics together.

Reflections from a Contextual Analysis of Two Sites and Two Projects

In this analysis we have explored key factors in the creation and facilitation of arts–science partnerships through the investigation of unique projects developed at geographically distinct sites. By narrowing the focus to issues of *enabling* and *situating* new forms of transdisciplinary creative practice, the analysis addresses concerns relating to the social and material infrastructures needed to support such collaborations. In the following section we present specific reflections drawn from both sites - a public arts organisation and a university art gallery - followed by a list of emergent insights from across the two arts–science projects, relevant to other collaborators working in similar ways.

A Public Arts Organisation: Supporting Collaboration and Collective Learning
Bundanon Trust encourages experimentation and transdisciplinary collaboration within the structured annual program and event *SiteWorks,* framed clearly as an exchange and an engagement with diverse voices and ways of knowing. This sets up a strong premise for participation, without prescriptive methods for collaboration. In this rural/regional context, the site itself influences what is possible for collaborative research; thereby encouraging the specificity of place to inform and determine what is worth doing, with projects 'giving back' to the environmental and cultural heritage of the site. *SiteWorks* and Bundanon Trust address an asymmetry in the provision of space for transdisciplinary arts–science partnerships, routinely inviting scientists into what is ostensibly an arts organisation.

SiteWorks participants identify collective learning as a potent aspect of the experience and of project development as a whole. By exploring other disciplines, participants become more self-reflexive and inventive because the explicit *SiteWorks* invitation encourages the exploration and development of new skills, methods and techniques. Gibbs (2014) suggests this opens up 'possibilities for observing and for asking previously unimagined questions; and presents possibilities for political engagement and communication with new publics' (pp. 223-224).

Within the context of this public engagement, it is possible to offer embodied and immersive learning experiences to audiences (as seen with *Black Nectar),* contributing to the development of deeper understandings and attachments to place and promoting an ethics of care for interdependent living systems. Furthermore, working closely within the complex physical environment invites an embodied research process. Gibbs (2014) calls this a collaborative, embodied research methodology, which she suggests provides an avenue for pursuing new imperatives in contemporary scholarship for impact, public engagement and Non-Traditional Research Outputs (NTROs).

A University Art Gallery: Supporting Collaboration and Collective Learning
UTS Art were supporters of O|M|H's collaborative process using the gallery as a place to present and discuss both independent art and contributions from UTS departments.

O|M|H successfully fostered partnerships between the university as a research institution, UTS Art as a cultural organisation and the broader community. While it was successful on many fronts, initial ideas for developing O|M|H as a living lab and a node in a network of related events was somewhat delimited by financial and infrastructural constraints. Taking a more process-oriented approach suggests a lab-like space to complement the traditional display spaces might enable more experimentation and collaborative activity to occur onsite.

Reflecting generally on the existing support structures, because there are no specific formal mechanisms to support collaboration, the success of new projects ultimately requires the dedication and capacity of academics and gallery professionals. Sociological asymmetries may prevent collaboration including funding, differing demands on teacher-researchers and arts practitioners, and work practices across different disciplines. The development of an appropriate, formalised process to support arts–science partnerships and transdisciplinary collaboration within the university context may help resolve such asymmetries and create greater opportunities for collaborators otherwise sidelined by them.

Regardless of the aforementioned constraints, the contemporary mission of many universities now involves inter- and transdisciplinary research and education, and University Art Galleries such as UTS Art are in a strong position to support and lead with this vision. University Art Galleries have the potential to foster sustained and diverse social aims and develop transdisciplinary outcomes aligned with a vision of the university as 'problem-solver'. By 'embracing shared interests and values, negotiating and respecting epistemology, and ultimately, collaborating across disciplines, the university art museum transcends traditional academic boundaries to augment critical thinking and integration of knowledge, the principle endeavors of the 21st century academe' (Rothermel 2012, p. 187).

Emergent Insights from Transdisciplinary Creative Partnerships

1. Creative collaboration relies upon open networks, experimentation and qualities of synchronicity and discovery. In both settings, an evolving and open framework for collaboration free of prescriptive methods or fixed certainties about *how* to work collaboratively was crucial. The transdisciplinary liaison began with discussion of principles and conversation that foregrounded what might be possible - rather than being driven by clear method and process - permitting the possibility to observe and understand how other collaborators do their work.
2. The collaborating scientists actively reached out to the arts to better understand how to address certain imperatives in their research. In each case the collaborations provided them new ways to think about the interaction of research with publics, the 'affective' dimension of the arts and the 'emotive' links between place, science and sustainability.
3. In response to the artist's keen interest in environments and ecology, some of the most influential moments emerged during field trips with biologists and ecologists. The scientists did not supply audio-visual material for artwork, but rather the contexts, data, knowledge and experiences that they implicitly understood would be catalytic.

4. The risk of being named 'activist' (and thus disregarded) is very real for scientists. This point of critical reflection in both projects highlighted a deep asymmetry between the expected roles and responsibilities of disciplinary experts. Artists are expected to transgress whereas the training and experience of scientists is to understand and avoid risks inherent in advocacy.
5. Disciplinary and institutional asymmetrical challenges identified in the research include differing publication validation systems and discipline-specific foci in terms of research. As science faculties rarely submit Non-Traditional Research Outcomes (NTRO) these kinds of transdisciplinary outputs do not enjoy the same weight, implying that science researchers risk being seen as non-strategic within their home discipline. In contrast academically employed artists can tailor their process to turn collaborative artworks and creative residencies into NTRO and TROs.
6. Collaborators from both projects were asked for their perspective on the key ingredients necessary for successful collaboration. These included: (a) generous amounts of time (b) clarity around boundaries and the limits of each discipline (c) mutual respect (d) a shared language (e) co-location (f) institutional license and will, and (g) "universal" values beyond the necessities of the market.

Supporting Creative Partnerships into the Future

Throughout this chapter we have presented some of the challenges in arts–science partnerships. Advocacy organisations such as the SEAD network are looking at ways to address many of the fundamental challenges including the need to 'generate and disseminate public dialogue about the intellectual, cultural and economic potential of creative intersections of art, science and technology' (Malina, Strohecker and LaFayette 2015, p. 3). Through our investigation we have looked especially at the challenges of enabling and situating new practice noting that public arts organisations and university art galleries are sites with the potential agency and flexibility to foster transdisciplinarity, where there is real support and a belief in its significance. They are also spaces where some of the sociological asymmetries of arts–science partnerships might be addressed by formalising the complex mechanisms and processes that support inter- and transdisciplinary collaboration.

While every context is different, there are certain features that we consider important in creating the optimal conditions to enhance the process and outcomes of collaboration. In terms of the spatial and technical aspects of displaying new works in a gallery environment, an optimal interior environment might be technically networked with experts on hand in online and mobile technology, access to collaborative display systems, personnel in the space during opening hours, a strong flow through of people with street visibility, a lab-like area designed for collaborative process and a space with lounge-like ambience for open and relaxed dialogue. Ultimately flexibility within a space is a key imperative. Where possible a steering group ("brains trust") drawn from several disciplines - artists, scientists, curators and academics - would be brought together to discuss the logistics, foreseeable problems and expectations of new proposals and potential connections. In terms of public engagement and education, a high-level

understanding of communications and social change theory is valuable, along with clear methods for outreach and education beyond the walls (or gates) of an organisation.

Arts–science transdisciplinary partnerships and the collaborative research that underpins them are dynamic and generative and open up scope for collective learning. By taking this direction, Armstrong and his co-collaborators, as well as his hosts, join a growing number of people and places choosing to channel their energies into work that emphasises inter-personal exchange, large-scale collaboration and social engagement. The challenges and opportunities are many, both in the creative process and the surrounding dialogue and debate that is generated when time and space is made available.

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