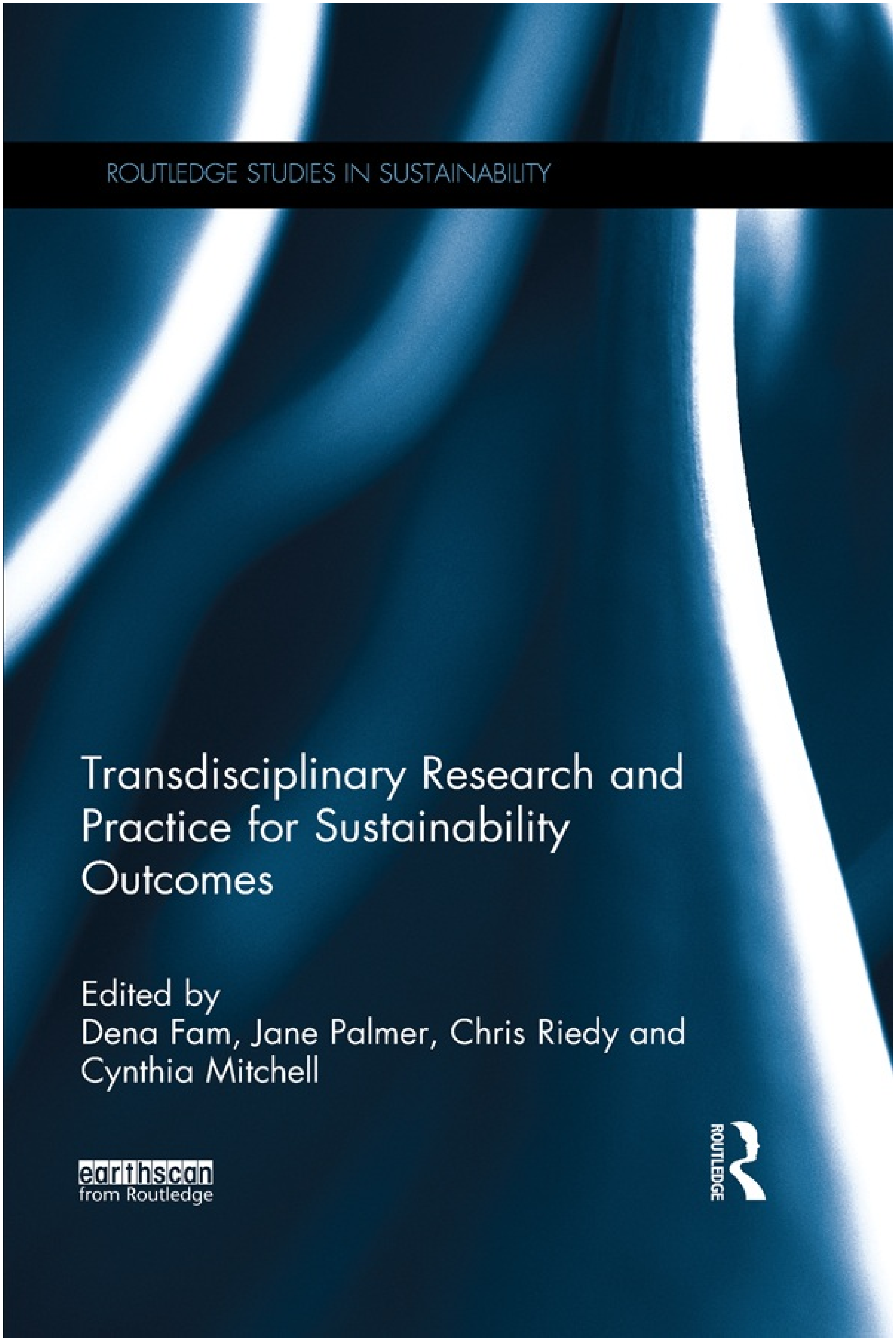
ROUTLEDGE STUDIES IN SUSTAINABILITY
Transdisciplinary Research and Practice for Sustainability Outcomes
Edited by
Dena Fam, Jane Palmer, Chris Riedy and Cynthia Mitchell
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# Transdisciplinary Research and Practice for Sustainability Outcomes

We know that the complex sustainability challenges facing our society today, including water and food security, poverty and climate change impacts, cannot be effectively tackled from a single disciplinary perspective. ‘Transdisciplinarity’ has emerged as a way of addressing these apparently intractable problems. Growing international interest in transdisciplinary approaches to research and practice, four decades of academic discourse and a significant body of work in this area, provide the background and opportunity for a specific focus on the practical application of transdisciplinary approaches to sustainability issues.

*Transdisciplinary Research and Practice for Sustainability Outcomes* examines the role of transdisciplinarity in the transformations needed for a sustainable world. After an historical overview of transdisciplinarity, Part I focuses on tools and frameworks to achieve sustainability outcomes in practice and Part II consolidates work by a number of scholars on supporting transdisciplinary researchers and practitioners. Part III is a series of case studies including several international examples that demonstrate the challenges and rewards of transdisciplinary work. The concluding chapter proposes a future research pathway for understanding the human factors that underpin successful transdisciplinary research.

As Emeritus Professor Valerie Brown AO notes in her Preface, this book moves transdisciplinary inquiry into the academic and social mainstream. It will be of great interest to researchers and practitioners in the fields of sustainability, qualitative research methods, environmental impact assessment and development studies.

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**Transdisciplinary Research and Practice for Sustainability Outcomes**
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# Transdisciplinary Research and Practice for Sustainability Outcomes

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Chris Riedy and Cynthia Mitchell

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# Contents

# Illustrations

## Figures

## Tables

## Box

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2014) and *Tackling wicked problems through the transdisciplinary imagination* (Earthscan 2010); with Judy Lambert, *Collective learning and transformational change* (Routledge 2013); with John Grootjans et al., *Sustainability and health* (Allen and Unwin 2005); and with Meg Keen and Robert Dyball, *Social learning and environmental management* (Earthscan 2005). Her website is www.valeriebrown.com.au.

**Dana Cordell** leads and undertakes international and national research projects on sustainable food and resource futures. Many projects involve high-level stakeholder engagement to improve societal relevance and foster mutual-learning. Dr Cordell co-founded and leads the Global Phosphorus Research Initiative – the first global platform to undertake transdisciplinary research, policy and public engagement to ensure food systems are resilient to the emerging global challenge of phosphorus scarcity. She currently leads the Sydney's Food Futures transdisciplinary project, which brings together key agriculture, urban planning and health stakeholders. As a global food security expert, Dr Cordell provides expert advice and commentary to the United Nations Environment Programme and to Australia's Chief Scientist. Dr Cordell's research contributions have led to numerous prestigious awards including one of Australia's top science prizes, the Eureka Prize for Environmental Research and a position in by the 100 Women of Influence (AFR/Westpac). She is frequently interviewed for media, including the BBC and the ABC.

**Dena Fam** is a systems thinker and transdisciplinary collaborator at the Institute for Sustainable Futures at the University of Technology Sydney. Over the last decade Dena has worked with industry, government and community actors to collaboratively manage, design, research and trial alternative water and sanitation systems with the aim of sustainably managing sewage and reducing its environmental impact on the water cycle. Her consulting/research experience over has spanned socio-cultural (learning for sustainability) institutional (policy analysis), technological aspects of environmental management. With experience in transdisciplinary project development, Dena is involved in developing processes for teaching and learning in transdisciplinary programs and projects. In particular she has been involved in documenting and synthesizing processes/methods/techniques supporting the development of transdisciplinary educational programs and projects. Dena has led and co-led international transdisciplinary networking events, grants and projects including an Australian-funded teaching and learning grant.

**Ray Ison** is Professor of Systems in the School of Engineering and Innovation, the Open University, UK. From 2008–15 he was also Professor at the Monash Sustainability Institute, Monash University, Australia, where he developed and led the Systemic Governance Research Program, an interdisciplinary, systems-based research program focusing on water governance, climate change adaptation and social learning. At the Open University he is a key member of the Applied Systems Thinking in Practice Group, and also contributes to the taught Masters in Systems Thinking in Practice. Through various commissioned projects and initiatives, his collaborative research demonstrates how social learning, including systemic inquiry, can be employed as an alternative governance mechanism for managing complex situations such as water governance, program and project governance, climate change adaptation, food security research, social learning, systems thinking and the purposeful creation of communities of practice. He is the author of the book (2010), *Systems practice: How to act in a climate-change world* (Springer & OU).

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**Julie Thompson Klein** is Professor of Humanities Emerita at Wayne State University. She has also been a Visiting Foreign Professor in Japan, a Fulbright Professor in Nepal, a Foundation Visitor at The University of Auckland in New Zealand, and Mellon Fellow in Digital Humanities at the University of Michigan. Holder of a Ph.D. in English from the University of Oregon, Klein is past president of the Association for Interdisciplinary Studies (AIS), former editor of the AIS journal *Issues in Interdisciplinary Studies*, and recipient of the Kenneth Boulding Award for outstanding scholarship on interdisciplinarity. Her books include *Interdisciplinarity* (l990), *Interdisciplinary studies today* (1994), *Crossing boundaries* (1996), *Transdisciplinarity* (2001), *Interdisciplinary education in K-12 and college* (2002), *Humanities, culture, and interdisciplinarity* (2005), *Creating interdisciplinary campus cultures* (2010), and *Interdisciplining digital humanities* (2015). She is also associate editor of the *Oxford handbook on interdisciplinarity (*2010, 2016) and co-editor of the University of Michigan Press series *Digital Humanities@digitalculturebooks*.

**Roderick J. Lawrence** graduated from the University of Adelaide (Australia) with First Class Honours. He has a master's degree from the University of Cambridge (UK) and a Doctorate of Science from the Ecole Polytechnique Fédérale, Lausanne (Switzerland). In January 1997 he was nominated to the New York Academy of Science. Since 2010, he has been Director of the Global Environmental Policy Programme at the University of Geneva in partnership with UNEP. In 2008 he was appointed to the Scientific Advisory Board of the Network of Interdisciplinary and Transdisciplinary Research by the Swiss Academies of Arts and Sciences. In 2011 he was appointed Adjunct Professor at the Centre for Environment and Development (LESTARI) at the Universiti Kebangsaan Malaysia (UKM). Since September 2014 he has also been Visiting Professor at the International Institute for Global Health at the United Nations University. His biography has been included in Marquis *Who's who in the world.*

**Abby Mellick Lopes** is a design theorist with 15 years' practical and academic experience in the field of design for sustainability. She is currently senior lecturer in the visual communications program at Western Sydney University, and a member of the Digital Humanities Research Group and the Institute for Culture and Society (ICS). Her current research projects explore the liveability of Western Sydney in a climate-changed future, and repair cultures in Sydney. She also researches in visual communications and has a long-standing interest in how image ecologies mediate socio-material relationships, which was the topic of her PhD titled ‘Ecology of the image’ (2005). She publishes widely, most recently contributing several chapters to *The Bloomsbury Encyclopedia of Design* (2016). In 2015 she co-edited a special issue on design and social practice theory for the international *Journal of Design Research* (with Dr Dena Fam), and another for the *Global Media Journal: Australian Edition*, entitled ‘Initiating change by design’.

**Catherine Manathunga** is a historian in the College of Education at Victoria University, Melbourne. She draws together expertise in historical, sociological and cultural studies research to bring an innovative, interdisciplinary perspective to educational research, particularly focusing on the higher education sector. She has current research projects on intercultural doctoral supervision pedagogy and the history of university teaching and learning in Australia and Aotearoa/New Zealand. Her most recent book, *Intercultural postgraduate supervision: reimagining time, place and knowledge*, was published in 2014 by Routledge. She has also co-authored: a monograph on educational history, *A class of its own: a history of Queensland University of Technology*; a co-edited oral history monograph, *Making a place: an oral history of academic development in Australia*; and has published in Australian, Irish, North American and British journals in the fields of international relations, higher education and academic development.

**Geneviève S. Metson** is a USA National Research Council post-doctoral researcher focused on sustainable resource management with a particular interest in food systems, waste and urban ecosystems. Drawing on systems thinking, ecology and sustainability, she has used both social and natural science methodologies to explore the opportunities and barriers to more sustainably managing phosphorus at the global, national and individual scales, and in cities across all continent with particular depth in Canada, the USA and Australia. After completing her PhD at McGill University in 2014, she was the recipient of the Australian government's competitive Endeavour Research Fellowship, allowing her to gain more experience with transdisciplinary work, including co-leading the P-FUTURES cross-city comparison network. She continues to successfully lead inter- and transdisciplinary teams through her involvement in the Urban Sustainability Research Coordination Network that is funded by the US National Science Foundation, and through work funded by the US National Socio-Environmental Synthesis Center.

**Cynthia Mitchell**'s passion for improving our collective ability to articulate, do, and value transdisciplinary research began when an engineering professor said of her research student's work, ‘I just can't see a PhD in this', and an education professor said ‘I can see three’. Cynthia is Deputy Director and Professor of Sustainability at the Institute for Sustainable Futures at the University of Technology Sydney, where she has been pioneering transdisciplinary research since 2001, principally in learning, water services and international development. She founded, and for 13 years directed, the Institute's higher degree research program. Her research has won national and international awards from academia and industry. She has an honorary doctorate from Chalmers University in Sweden for her interdisciplinary work for the environment, and is a fellow of the Academy of

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**Jane Palmer** is a Research Fellow at the Institute for Resilient Regions, University of Southern Queensland. She has degrees in philosophy and architecture, and a doctorate from the Institute for Sustainable Futures, University of Technology Sydney. Her doctoral research was based on ethnographic fieldwork in Indonesia, and she has since been appointed to research fellowships at the University of Newcastle (Australia) and the University of Southern Queensland to undertake ethnographic projects in regional and remote Australia. Prior to her academic career, she worked for several years in northern Australia with Indigenous communities as an architect and project manager. Her research interests include the use of ethnographic storytelling methods to explore the processes of trauma, grief, resilience and adaptation. Her current projects are focused on supporting communities in South-West Queensland to engage with cultural heritage and explore its connection with wellbeing. Jane has published in the areas of ethics, fieldwork methodologies, futures studies and climate change adaptation.

**Chris Riedy** is the Director of Higher Degree Research at the Institute for Sustainable Futures, University of Technology Sydney. Chris applies futures thinking, participatory processes and social theory to practical experiments in transformative change for sustainability. Between 2014 and 2016, he helped the Wintec Institute of Technology in New Zealand to establish a new Master of Transdisciplinary Research and Innovation. He runs workshops on cross-disciplinary supervision at the University of Technology Sydney and is currently developing a transdisciplinary learning lab to give research students a taste of transdisciplinary research. Chris is a Senior Research Fellow of the Earth System Governance project and a member of the editorial boards for *Futures* and the *Journal of Futures Studies*. He has published 35 peer-reviewed articles, one book and more than 50 research reports. He writes a blog on thriving within planetary boundaries called PlanetCentric (http://chrisriedy.me).

**Katie Ross** is curious about ways to create change. She wonders what types of strategies and approaches work best in certain situations, and what 'palette' of approaches leads to the most meaningful and well-directed change towards sustainable futures. Luckily, she is a Research Principal at the Institute for Sustainable Futures (ISF) at the University of Technology Sydney, where she can explore this interest daily. She specializes in transdisciplinary action research that agitates for change in social, technical and governance systems. Katie has more than 10 years' experience working in sustainable development, resilient service systems and innovative capacity building. Since joining ISF in 2010, Katie has led and contributed to applied research in ISF's renewable energy, climate change mitigation/adaptation, water/sanitation, international development and gender/equity research areas. Katie has qualifications in environmental science (Columbia University) and sustainable development (Victoria University / Macquarie University), and is pursuing her doctorate on the impact of tertiary transdisciplinary learning and service learning.

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**Zoe Sofoulis** is an interdisciplinary cultural researcher with a long-term interest in the social, cultural and irrational dimensions of problems normally addressed through techno-scientific rationality. She has led projects on everyday water users and urban water industry managers, and co-designed the ‘Water Diary’ exercises subsequently adapted by other household water researchers. Expanding the scope of social and cultural research that informs urban water management was the goal of her 2010–11 National Water Commission Fellowship *Cross-connections: linking urban water managers with humanities, arts and social sciences researchers*. She has helped organise events for water researchers from different disciplines and sectors, and co-edited two collections of papers from the most recent of these (*Local Environment* 2015, 20(5); *ACME: The International Journal of Justice and Sustainability* 2015, 14(3)). Her ideas about knowledge ecologies were initially developed as part of the ICS-funded project Knowledge Ecologies Workshop (2012–14).

**Juliet Willetts** leads research to influence policy and practice in international development. For more than a decade she has led transdisciplinary research projects in this context, addressing the human right to water and sanitation and also making contributions to gender equality, sustainability, civil society role in development, and innovation in monitoring and evaluation approaches. She has supervised transdisciplinary doctoral researchers since 2002 and has contributed to intellectual leadership of the transdisciplinary higher degree research program at the Institute for Sustainable Futures, University of Technology Sydney over many years. Juliet serves as academic Co-Chair of the *Research for Development Impact Network* and is a founding member of the *Water, Sanitation and Hygiene Reference Group*, a policy reference group. She has received an international research award and multiple UTS awards for research excellence, human rights and social justice, and was a finalist in the 2014 National Australia Bank's Women's Leadership awards.

**Jennifer Williams** is an information designer, educator and researcher who has practised and taught for the past fifteen years in Australia and New Zealand. Her principal focus lies in expanding visual communication designers' roles within transdisciplinary design both theoretically and in the field, as well as advancing implications for design education. She was an Early Career Researcher (ECR) and co-leader of the Visual Communication strand in the two-year UTS Challenge Grant project, ‘*Transitioning to sustainable sanitation*’, 2010–2012. As a design practitioner, Jennifer has worked most notably for the Museum of New Zealand (Te Papa Tongarewa) where, as a member of the initial transdisciplinary core design team, she designed a number of exhibitions, pan-museum signage and wayfinding systems.

# Preface

## Transdisciplinarity: a way of the future?

This book moves transdisciplinary inquiry into the academic and social mainstream. There is help here for diverse readers seeking a better understanding of what is happening to their society and their planet – the anxious individuals, disturbed communities, confused experts, frustrated organisations and hopeful agents of change. The increasing visibility of transdisciplinarity as a whole is demonstrated by the examples in the book's sections on change management, research practice, change agency and future directions. Together, the chapters flesh out the practice of transdisciplinary inquiry as a task for all comers, rather than a boutique enterprise. The question this book can help to answer is, have the hopes of those who originally invented the idea been realised?

The birth of transdisciplinary inquiry is attributed to transdisciplinarians Jean Piaget of Switzerland and Erich Jantsch of Austria. In the early 1970s they began separate discussions that continue to this day. There was then no language to describe the phenomenon so they called their topic 'Interdisciplinary', a term as controversial then as transdisciplinarity is now. Both of them regarded the then current monopoly of the disciplines on constructing new knowledge as deeply unsatisfactory. Piaget (1973) called communication between two disciplines 'a dialogue of the deaf'. Jantsch (1972) deplored compartmentalised forms of knowledge as having 'a lack of individual meaning, lack of relevance and absence of a critical synthesis'. At the same time, they both held visions of a time when this new form of scholarship would become the leading way of thought.

They would both be pleased to find the breadth of practice and the depth of theory recorded in this volume. They would also find the two schools of thought which have existed from the beginning, and which are reflected and recombined there. Piaget places transdisciplinarity as operating within academia and Jantsch sees it as dispersed throughout the community. Piaget proposed structures that bring together the existing forms of disciplined inquiry; Jantsch argues for breaking new ground in thinking about complex issues.

Piaget followed the lead of the early quantum physicists in searching for the relationships within the existing system of inquiry. His stated goal was a synthesis that included the full range of academic disciplines. He wrote of the need for transdisciplinarity to bring together different sets of rules, values and meanings. On the other hand, Erik Jantsch expected transdisciplinarity to produce a more complete and accurate vision of reality by integrating different ways of understanding. He wrote of human learning as a self-organising, self-renewing and self-maintaining system.

Recognising the need to combine a coordinating structure *and* open-mindedness, both thinkers point to a third possibility: the joining together of their own positions. Other divided traditions that they hoped would be brought together included diversity *and* unity, creativity *and* rationality, individuals *and* the collective. Both thinkers gave us a yardstick by which to measure progress towards establishing this third collective possibility. Jantsch hoped for the day when transdisciplinary thinking would value process over structure, uncertainty over equilibrium, evolution over permanency, and individual creativity over collective stabilization. Piaget writes of the need for a structure that recognizes a whole that is distinct from its elements, that achieves a fresh whole rather than continuing loyalties to existing divisions, and that has rules that permit re-organization from within. This is a powerful pair of prescriptions for a future transdisciplinarity.

From nearly half a century ago, these propositions reach out into the present. Taken together, they suggest criteria for a collective, inclusive, forward-looking transdisciplinarity. The four parts in *Transdisciplinary Research and Practice for Sustainability Outcomes*, namely, change management, research practice, change agency and future directions, mirror these projections. A summarizing lens helps us explore whether this book is helping create the future that early transdisciplinarity hoped for. In short, Piaget and Jantsch asked for:

- a unifying structure that allows for both the independence of the parts and their recognition as wholes;
- a value orientation for transdisciplinarity which requires changes that go beyond current social practices;
- a set of rules which permit, and even encourage, uncertainty and creativity in a self-organizing system of knowledge.

The important question to ask here is, do the 17 chapters that make up this book, taken together, reflect these three propositions for a future transdisciplinarity? Reading the book reveals that each of the chapters has a unifying framework, and all support the value of transdisciplinarity. The parts that make up each framework have a strong presence in their own right. Throughout the book uncertainty is expected and creativity encouraged. The hopes of both Piaget and Jantsch have been largely fulfilled, although not in the ways they might have expected. Competing schools of thought remain. There are still the differing directions taken by the compartmentalised academic and open community-based orientations, originally represented in the work of Piaget and Jantsch.

The choice of synthesising structures and their parts is a vital part of the current transdisciplinary story, a story that can be followed through the chapters of this book. In Part I, each of the chapters is based on a unifying structure, each structure having its own set of rules. One such unifying structure is the long-sought unity of knowledge, with the parts being the socially-determined knowledges. Another chapter structure is an orientation towards outcomes, with the parts being the set of problems which need to be resolved. A proposal for a systemic framework offers task-appropriate packages of tools; and a systems framework accepts uncertainty as inevitable when the parts include conflicting sets of interests.

In Part II, supports for transdisciplinary research practice are described in the twin contexts of academia and the wider community. Some of the chapters document the support for transdisciplinarity available within academic institutions, where social pressures and opposition can be strongest. They demonstrate that rules can still be broadened to recognise the individual needs of each researcher, to support creative thinking and to celebrate the use of the imagination. In the community ontext, the wide canvas of different ways of knowing becomes the core of the enterprise. The traditional dominance of science is acknowledged, and so are the different ways of understanding that underpin different constructions of reality.

Part III brings with it great hopes for the future, combining the direct experience longed for by Jantsch and meeting Piaget's challenge for organised structures. The disciplinary fields used to structure the accounts of direct action include the biological sciences, ethnography, agriculture and ecology. Imaginative ideas which could carry transdisciplinary practice into the future include: cross-cultural collaborative learning; all participants ‘being present’ in the project; and researchers' reflections on the issues. Researchers' reflections on the issues allow them to recognise their own version of reality, and their own values, ethics, aesthetic responses and sympathies.

A constant theme generated by the practical examples was the need for a common language that could link the disparate participants of a transdisciplinary project. Suggested solutions include storytelling and sensitive community development strategies. Systems-based ideas could be shared through diagrams, song, drawings and dance. Some projects sought to develop empathy among the members of diverse ethical systems. Other projects sought mutual understanding of the importance of the sustainability of the participants' shared landscapes. Future-oriented ideas included consideration of potential physical, social and ethical boundary issues; structures for collaborative participatory project design; and recognition that all translation creates a third language which needs to be negotiated among the participants.

At the beginning of this valuable book, the author of Chapter 2 reviews the widely varied notions of transdisciplinary research and discusses its status in academia and mainstream thinking. Klein does not consider that its sustainability is assured. It is clear that neither Piaget's wish for shared structures nor Jantsch's hope for enriching self-organisation have yet managed to establish transdisciplinary thinking as the mainstream.

On the other hand, the work presented in this book establishes that this is not for want of trying – and that there have been some considerable successes. The dreams of the originators of transdisciplinary inquiry have found a place of record. There is evidence here that transdisciplinary research has begun to practise what Piaget and Jantsch were preaching nearly two generations ago. In this book you can find a wide range of a structures, values and rules which can put into effect both an academic and a community-wide transdisciplinarity. Piaget and Jantsch would be delighted.

Valerie A. Brown AO, Canberra, 22 April 2016



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# 16 Trouble at the disciplinary divide

## A knowledge ecologies analysis of a co-design project with native Alaskan communities

*Dena Fam and Zoe Sofoulis*

### Introduction: a knowledge ecologies approach to understanding transdisciplinary processes

This case of transdisciplinary collaboration raises a range of issues relevant to scientific research on complex twenty-first-century problems associated with water security, energy consumption and climate change impacts. These problems are widely acknowledged to require more than technocentric and resource-centred solutions, and they demand increased engagement with the people impacted by the problem, and with those who will live with the proposed solutions. This suggests a greater role for researchers from humanities and social science (HASS) disciplines in fields conventionally dominated by STEM (science, technology, engineering, mathematics) knowledges. But bringing together positivist (quantitatively oriented) and interpretive (qualitative) paradigms of knowledge has its own difficulties, not least the effort to establish ‘a basis of mutual intellectual and professional respect’ that could ground a ‘genuine’ knowledge partnership (Nowotny et al. 2013).

These two paradigms have very different ideas about the nature, generalizability and the purpose of knowledge. One theorist of water governance summarizes these differences:

> [P]ositivism sees the researcher and reality as separate, there is only one identifiable reality and the purpose of research is to control and predict. Interpretivism, on the other hand, notes that the researcher and reality are inseparable realities, are mental constructs in that they are social and experienced-based and there are multiple realities, which are dependent on the interpretation of individuals.
>
> (Meissner 2015, 3, citing Lincoln et al. 2011)

The very contrast between these paradigms, Meissner points out, that positivism is not the only legitimate way of doing research; nor is it the only basis for theories of reality (2015). Positivists' beliefs that their reality is *the* reality, and that scientific method is *the* only valid method, are themselves obstacles to overcome in order to achieve successful transdisciplinary collaborations with researchers from different paradigms.

Most project teams cease to exist once funding is exhausted, the report is in, or the design is finalized. Rarely do they reflect upon and write about the process of collaboration itself in order to pass their lessons on to others. Unusually, the case study in this chapter is of a team whose enthusiasm and motivation to learn from their experience persisted after the proposal submission date, allowing the lead author (Fam) to conduct semi-structured interviews with fellow team members to reflect on the collaborative process and the value of social research in engineering projects. Their open and thoughtful responses, articulating key challenges for integrating knowledge from different paradigms, and offering suggestions for overcoming them, form the basis of this chapter.

‘Transdisciplinary' research sometimes gets stuck in a narrow understanding of ‘knowledge integration’ that can compound rather than ease, problems of collaboration. All too often, knowledge integration as a *goal* – bringing different knowledges to bear on a problem in order to find a more multi-faceted, complete and ‘integrated’ solution – is assumed to work via an homogenizing positivist *methods*, for example in efforts to reduce humanities and social sciences knowledge to ‘social data’ that can be incorporated into STEM-dominated projects or fed into modelling software. The idea of a knowledge ecology is proposed as an alternative to ‘integration’; it is a way of thinking about the relations between different kinds of knowledge that does not try to assimilate them all into the ‘master discourse’ of positivist science.

‘Integration' is especially problematic when teams combine positivist science and engineering approaches with post-positivist and interpretive perspectives, because of deep differences in perspective on the form, purpose and value of knowledge, as well as the roles of the knower and research subjects in knowledge production (Sharp et al. 2011). Rules of evidence are very different for interpretivists, for whom in-depth studies of a small number of cases are valued for the complex relations they reveal amongst heterogenous factors, and for whom the quest is not for predictive knowledge but insight into the values, meanings and narratives that motivate social and technical practices, as articulated by the subjects of social research as well as by researchers.

In this chapter we adopt the concept of knowledge ecologies (KE) (Sofoulis and Hugman 2012; Sofoulis 2015), employing a template used by ecosystems scientists for making analytic descriptions of ecosystems and translating this into concepts appropriate for assemblages of knowers and knowledges (see Figure 16.1). Where the ecosystems scientist would start with an inventory of the biotic (living) factors such as flora, fauna and microorganisms, as well as the abiotic (non-living) factors such as climate, geography, hydrology, nutrients and their various interactions, a knowledge ecologist would describe the groups of knowers and knowledges working around some common problem. Equivalents of ‘abiotic factors’ are in the operating environment, including the policy climate, official research priorities, incentives and rewards, and material facilities, like research centres, networks and funds. As in the biological world, interactions between different knowers and knowledges could be parasitic, competitive, cooperative, or part of a food chain. The KE approach considers how ‘abiotic factors’ tend to advantage some kinds of knowers and knowledges over others. It also looks at how boundaries between knowledges and knowledge ecosystems are maintained or crossed, for example through knowledge translation and exchange. Finally, it considers evolutionary changes, identifying sites and ‘species’ undergoing transformation, whether from internal or external pressures or through hybridization.

| ECOSYSTEM | KNOWLEDGE ECOLOGY | COMPONENTS |
|---|---|---|
| 1. Biotic factors (organisms) | Knowers and Actors Knowledges and Modalities | Different kinds of knowers and knowledges brought to bear on a problem or project.<br>Research modes, methods, evidence standards. |
| 2. Abiotic factors (climate, geography etc) | Policy Settings and Resources | General policy climate and knowledge landscape.<br>Resources: research funding and infrastructure, centres and networks. |
| 3. Interaction of biotic with abiotic factors | Knowledge/ Power/ Resources | Conditions of knowledge production.<br>Distribution of research resources.<br>Interactions between different researchers and fields enabled or constrained by access to resources. |
| 4. Interaction among biotic factors | Relations between knowers, knowledges; knowledge practices | Interactions on multi disciplinary teams, and with communities.<br>Knowledge 'food chains', parasitism, predation, symbioses, etc.<br>'Charismatic mega-fauna' (Big Names). Endangered knowledges, monocultures. |
| 5. Inside & outside system boundaries | Boundaries, Translation, Sources, Contributions beyond | Drawing, defending, transgressing boundaries around disciplines and expertise.<br>Knowledge transfer, translation, brokering.<br>Site specific and untranslatable knowledges. |
| 6. Evolution | Evolution of new or altered knowledge ecologies | New kinds of knowers and knowledges and how they are emerging.<br>Successful pathways for knowledge transfer, translation and collaboration. |

*Figure 16.1* The Knowledge Ecologies framework

Source: Adapted from Sofoulis 2015.

The rest of this chapter is structured in accordance with this framework, beginning with the cast of actors that figure most significantly in this particular ecosystem, especially the project team itself. It then examines the Alaskan Water and Sewer Challenge (AWSC) as a major 'abiotic factor' that sets the scene, and whose internal contradictions reflect more general features of the policy environment in which the project team proceeds.[1] We then consider how the distribution of funding and time affected the interactions of people on the team and project outcomes, focusing on the shifting role of the social research component in relation to the technical design process. The final sections reflect on the importance of translators and translation in enabling communications across paradigms in transdisciplinary projects, and the learnings and discoveries that team members made in their collaborative process.

## Biotic factors: knowers and knowledges

The primary actors ('biotic factors') in this knowledge ecosystem were the AWSC Steering Committee, the small project team, and native Alaskan community members, who worked at different levels of governance. Other significant actors were the Alaskan Department of Environment and Conservation (DEC) which funded the project, and regional health consortiums.

### *A diversity of knowers*

#### *The steering committee*

The AWSC Steering Committee was responsible for putting out the international call for proposals from DEC, evaluating the responses, and deciding which international teams would be funded and would move forward in the process. This committee consisted of professionals with significant expertise that included administrative perspectives of local government and spanned the breadth of positivist STEM perspectives on problems in remote Alaskan communities: Arctic engineering, civil engineering, biology, veterinary sciences, chemistry, environmental toxicology and environmental health. Although the call for proposals explicitly asked for design thinking and community engagement, the exclusion of HASS expertise from the steering committee indicated a low commitment to understanding how those processes worked, how they might be appropriately operationalized, and how projects might be evaluated according to social as well as techno-scientific criteria.

#### *The project team*

The constitution of the project teams was shaped by the initial AWSC call, which specified skill sets that mirrored those of the steering committee:

- engineering design and construction;
- water and wastewater development in remote and austere environments;
- developing alternative and non-traditional sustainable approaches to addressing water and/or sewer needs;
- evaluating public acceptance and receptivity of health-related technologies;
- using design thinking for technology development.

In our case, project team members (including Fam) were professionally acquainted and chose to come together to respond to the Alaskan Water and Sewer Challenge. The team consisted of five members, one microbiologist with indigenous health and public health expertise, two engineers with experience in decentralized water and sanitation systems in the Arctic, and two design consultants with backgrounds in chemical engineering and industrial design and familiarity with design philosophy, participatory design, and practice theory (Fam and Mellick Lopes 2015). All team members were committed to community engagement and saw social research as crucial to the research and design process.

### *Native Alaskan community members*

The AWSC brief specified that water and sanitation designs ought to be applicable to all 300-plus remote native villages, and accordingly invited each international team to work with two villages during the design phase. It was hoped that exploring similarities and differences between the two villages could help improve the design relevance across the larger number of Alaskan villages. The two villages assigned to the project team had similar demographics (95 per cent native), were of different sizes (150 and 450 residents respectively) and varied in terms of geography and climate (one south and one north of the Arctic Circle) and governance (unstable tribal administration versus stable city council). Tribal elders, councils and local governments involved in community decision-making determined the roles of local administrators who were responsible for maintaining and operating water and sewerage systems.



## ***Diverse types of knowledge***

Local knowledge was an important type of knowledge, whether of village water and sanitation history, the economic viability of alternative systems of service provision, or the long-term social and cultural acceptability of these systems in everyday practice. The villagers themselves had already managed their own sewage and water systems, either individually or through council services, sometimes for significant periods. Across different levels of governance within local villages, household residents, city and tribal council members and regional health corporations had gained significant expertise from having lived with failed sanitation systems and endured their health implications.

On the design team itself, differences between positivist and interpretivist paradigms became evident in the ways different team members understood the nature and purpose of knowledge, and how different expert knowledges related to each other and to local knowledges. These differences were not only in disciplinary language, but also in the conceptions of what knowledge is.

One team member with a strong preference for knowledge that was useful, and who needed ‘something tangible that … can be used in practice,’ was initially suspicious of social science and planning inputs to technological design projects, because:

> Normally a lot of that stuff is … not real specific or concise. … [T]here aren't really real firm constraints. That type of information oftentimes gets to be … I don't know. From an engineer's perspective, I would say really grey.

Like others on the team he compared engineering knowledge to social research knowledge in stark terms: ‘black and white’ compared to ‘grey’ and ‘hard’ or ‘firm’ compared to ‘soft’:

> It seems like for researchers and people on [the social side] of things … everything is

> open and debatable and you can discuss and consider and evaluate and talk about and look at cultural significance, and, you know, you can do all of this grey stuff. But on the engineering side of things, most people that work on that side are really used to working within some pretty firm project constraints.
>
> (Arctic Engineer)

Another team member had come to see how engineers' insistence on black and white knowledge limited their capacities to respond innovatively to societal needs:

> [T]he engineers are very black and white … they say they're problem solvers, well they're really just project managers … So they set a lot of rules that they follow, there's codes of practice … So they're very used to a black and white world and they're good at troubleshooting on site to adapt to … fit that particular house or that environment. That's about as much flexibility as you tend to see with engineers. But the whole concept of framing the water service based around what society really wants water for, and how to deal with sanitation … that's not their brief. They just answer the brief given to them to build the … whatever.
>
> (Public Health Expert)

The preference for black and white engineering knowledge over grey and fuzzy qualitative research harks back to the longstanding modern disciplinary divide, where the tendency Latour (1993) calls 'purification' separates disciplines along the fact/value divide, or it separates natural/technical issues from social concerns. A tendency to resort to discipline-based expertise manifested in the team, when the 'technical' design group attempted to separate from the 'social' design group. The latter adopted a transdisciplinary approach and wanted to strengthen links between social and technical issues, based on the logic that new technological infrastructures need new social infrastructures to implement and manage them, and that trials of technical prototypes therefore needed innovative social and institutional arrangements or 'management prototypes'.

## Abiotic factors: Alaskan water and sewer challenge (AWSC)

The team was funded to develop its Alaskan Water and Sewer Challenge bid in competition with other teams, one of which was to be selected to prototype and trial the final design of an integrated water and sanitation system for remote Alaskan communities. Actual 'abiotic' ecosystem factors like climate, geography and hydrology are relevant to the design proposals, but here we focus on their metaphorical equivalents in the project's operating environment: the policies, priorities, guidelines, facilities, funds and infrastructures that constrained and enabled team actions and project outcomes. Prominent in this landscape was the challenge itself, especially as manifested in the original call and in subsequent revisions of project parameters.

The AWSC both expresses and responds to a pre-existing set of political and economic factors, especially the withdrawal of remote area government services and the consequent need to find lower-cost water and sewerage systems for the villages. But the AWSC contained contradictory injunctions and constraints. Unusually for a competitive engineering design process, it mandated that community engagement be embedded across the whole research design, and not isolated as an add-on. It had the novel objective of including social knowledge via design thinking, an approach that draws on systemic thinking to explore innovative solutions and desired outcomes that benefit end-users (Cross 2011). However, the AWSC became more like a typical technical design exercise when a series of amendments specified design criteria that prescribed acceptable water sources and volumes, average household size and monthly cost, all at great variance from the parameters the team discovered by asking the villagers. The new criteria put further constraints around the kinds of solutions that would be considered acceptable, and reinforced restrictions already established by the initial assumption that the chosen solution would be a one-size-fits-all system rather than, say, a range of independent systems that suited a diversity of geographic, demographic, cultural and governance formations found across the 300-plus remote communities.

Without inside knowledge of the DEC and the AWSC Steering Committee, we can only speculate about how the initial call and later amendments came to express such divergent and clashing perspectives on the design of alternative systems in water infrastructure planning. This is surely not the only initiative in a STEM-dominated field where aspirations toward innovative community-driven and/or interdisciplinary solutions are countermanded by conventional engineering perspectives that impose limiting assumptions about the types of design processes and solutions that might evolve. In essence the AWSC called for international expertise in design thinking, but by operationalizing design thinking within pre-existing networks, knowledge infrastructures and expertise, it encouraged a ‘business as usual’ approach that limited the scope for innovation.

## Biotic and abiotic factors: resourcing different knowers and knowledges

Like an ecosystems scientist who studies how organisms interact with their environments, the knowledge ecologist is interested in the access different types of knowers have to resources for knowledge production, which determines the relative status and power of different species of knowers and knowledges. Knowledge ecology here turns into a kind of political economy. In an ideal realm, all knowledges might be equal, but in the real world of funded research, ‘some [theories] are more equal than others’ as Meissner (2015, 5) puts it, with positivist science being much ‘more equal’ than social research in water management and governance, and funding is allocated accordingly.

The team included engineers who were transdisciplinary researchers with extensive experience in design thinking and community consultative approaches, who took seriously the catch phrases of ‘design thinking’ and ‘community engagement’ that had found their way into the AWSC call. But as already noted, the call and its modifications also reproduced conventional water and sanitation project priorities, and the small amounts budgeted for those components reflected normal engineering project conventions. One senior researcher/designer explained what had happened:

> Well it is because you take an engineering rule of thumb and you go okay one per cent of the cost of the [project] is design … and so that's what we'll allocate to this bit [social research] up front. A lack of understanding [by] the people who are designing the budget portions across the whole [project] of the importance of social research [meant that] even though someone had managed to get design thinking in [the proposal] … the budgets were really tiny.
>
> (Design Consultant)

The budget allocations for AWSC bids did not reflect the practical reality of funding international researchers to visit, and get to know, remote Alaskan communities and involve those communities in the design process. They would only have been enough to fund a short survey to gather data about historical and proposed water and sanitation systems. This extractive survey approach is the opposite of the more extensive fieldwork and iterative participatory processes implied by 'design thinking' and 'community engagement'. Such a disparity between the expected degree of engagement and the size of the social research budget is not uncommon in water and sanitation planning exercises:

> [T]his happens all the time on our projects. Where the client will budget us one day to go to the community, collect some information and come back, and that's it. We can never get everything we want. We can never talk to all the right people we need to and such. … if it's just something simple like go out to this utility, look at the site, they need a new tank, put in a new tank for them. That's simple. But when you're talking about doing things that are going to change people's lives then I think the social research is critical for … developing those relationships.
>
> (Arctic Engineer)

The project team tried to mitigate the weight of this convention by allocating a substantial proportion of its funding to the social research component, with all team members donating significant blocks of time to other project components. Yet despite all members appreciating the value of an iterative engagement process, funds were exhausted before the final stage of community engagement could be implemented. Instead, a workshop was held bringing social and technical parts of the team together to firm up the proposed design. Finally, the design team resorted to sending questionnaires to community leaders for feedback, which was disappointing for all concerned.

> I think it's still very essential, is get back to the communities to do a few iterations. Okay, we've heard what their interests are and what may be possible. We've come up with a design. We need to go back and really in a social context talk through that, weed out and refine that, rather than come up with our *fait accompli*. So to me, that was unsatisfactory or unsatisfying.

(Public Health Expert)

## Interactions amongst the knowers and knowledges

There is a multitude of relationships that could be examined in this project, but here we focus on the scientific and technical experts, the transdisciplinary social researchers, and the two remote communities representing the intended end-users, and how interactions between them were both constrained and enabled by the context of the project, and the distribution of resources within it.

The more positivist members of the team had preferences for extractive models of social research to engage the communities, surveying preferences, aspirations and viability of technological solutions. In contrast, the more interpretivist members of the team leant toward a participatory, action research model of community engagement, which sought co-design methodologies including iterative approaches to the design process. As one team member described it, the normal process is for engineers to respond to a problem or a design brief with limited interaction with the users:

> from an engineering context where you go in, you've got a job, you go in, you build it. You're not thinking necessarily about what is perhaps the preferred system here; it's just going in and putting in one of these and deal with it. It's a different …interaction.

(Public Health Expert)

The agreed plan for community engagement was an iterative one where the design consultants were to make two field trips to each community, the first to acquaint themselves with community members, find out about their knowledge, prior experience, interests, needs and capacities for sewage management, and to feed these insights into the technical design process. The immersive approach taken by the authors' team involved design consultants spending two weeks within the selected sites, and holding conversations with 25 participants from the villages, regional health consortiums and state-wide organizations to gather qualitative data to set social and cultural parameters for how the system might be designed. Follow-up visits had been planned to present and discuss the proposed design(s), which would be modified again in response to community feedback. However, as mentioned, budget constraints meant these visits did not eventuate.

In reflecting on how the project management could have been done differently, team members acknowledged the need for a translator or knowledge broker between social research and engineering design who could create a 'stepping-stone' and negotiate across and between disciplinary perspectives. Such a 'hybrid specialist' (Mitchell et al. Chapter 12, this volume) could facilitate 'making sense together', as Klein puts it (Chapter 2, this volume), promoting the 'intersubjectivity' needed to achieve mutual understanding of the situation and how to move forward together. In such situations, the social researchers may need to move first:

> The people who are on the odd island out are the ones who must move. So social

scientists cannot – I'm sorry but at this point in our history and it's a sad thing but social scientists cannot expect engineers to walk over to their island. Social scientists have to go the other way and they need help. They need to pick up an engineering translator along the way.

(Design Consultant)

## Translation across knowledge boundaries

Team members came from vastly different disciplinary and knowledge perspectives in regard to water planning. Although the more positivist inclined members of the team were uncomfortable with knowledge that wasn't 'black and white' and presented in a quantitative form, the social design team nevertheless found other ways to bridge the boundaries between social and technical knowledges, as illustrated by three examples.

### *Visualizing the socio-technical system*

Early on in the project, there was a need to articulate upfront the range of contributions team members would make, while at the same time helping s everyone rethink their ideas about relations between the social and technical components of the design. Accordingly, Figure 16.2 was a visual aid produced aa translation device. This system diagram visualized the relationship between 'hard' (technical/ resources) and 'soft' (social/ governance) components, and highlighted the critical need to engage villagers at different levels of the community and governance organizations. The lower section of the diagram lists human elements less familiar to engineers: components such as social acceptance; the everyday practices, preferences and skills necessary to use, operate and manage a system; and institutional responsibilities and community capacities for managing and operating systems and so on. The diagram aimed to illustrate how these elements were intertwined with technical considerations.

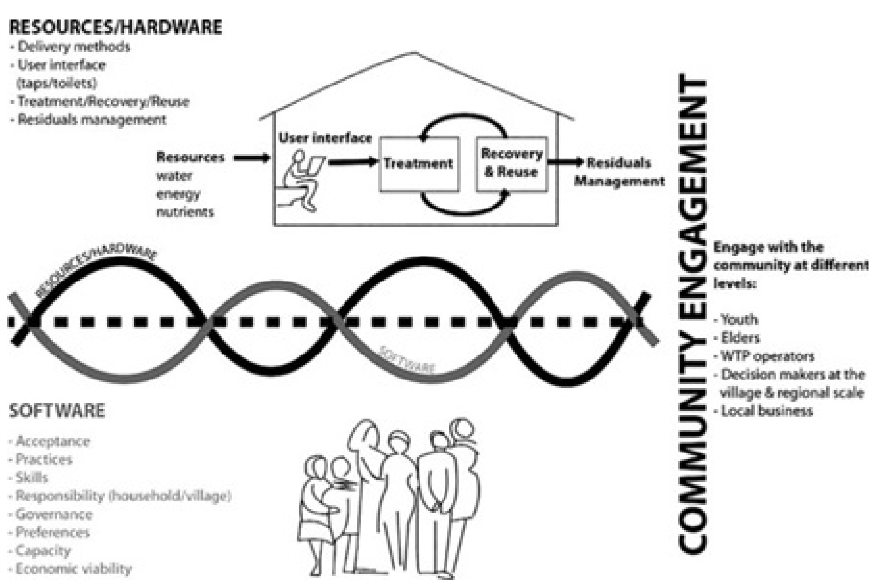

*Figure 16.2* A visual translation device to help participants think about interactions of technical (‘resources/hardware’) and social (‘software’) factors

### *Using words as bridges*

A second kind of translation technique was linguistic. It involved the use of engineering language to help explain and interpret social data by translating social and cultural findings into a language all team members could relate to and easily use. One example of positioning a concept between positivist and interpretive meaning was the use of the term ‘management prototyping’ to highlight how technical innovations also require social innovations to bed them in. Prototyping, the term for a typical engineering practice, was put to work as a conceptual bridge to the social dimensions of water management, as this team member explains:

> [Engineers] know how important it is to prototype technologies … So having that kind of concept which has a whole lot of value in their world associated with something that there's sort of a vague understanding that there is something important there, but it's too hard, or it's somebody else's problem, or this community is dysfunctional anyway so they'll never work, or whatever set of perspectives and experiences people have … it ['management prototyping'] was a way to kind of cut through that.
>
> (Design Consultant)

### *Design principles: distilling social research findings*

A third and particularly effective translation device developed in this project was a set of 12 design principles (see the appendix to this chapter), which synthesised findings from the community engagement process. The social research revealed issues related to cultural water use practices (hauling water from historical sources i.e. ice, rivers, rainwater, wells), social acceptance of water sources (i.e. preference for the taste of raw versus treated water), and institutional issues associated with managing, operating and maintaining local sanitation systems and the skills and finances required to do so in practice (i.e. the motivation to pay, or the capacity to bill for sewage disposal). Importantly, many of the issues incorporated into the design principles concerned cultural, economic and political issues influencing the success of the system over the long term, rather than the technological aspects of the system design.

All team members found the design principles a valuable tool that encapsulated ideas in a manner tangible enough to use in engineering practice, and diverged from the usual ‘building block’ model of data-based knowledge. Moreover, the design principles worked to anchor the technological solutions within a real-world context, reminding team members of the parameters and capacities of the communities where the technologies were destined to be implemented.

> I think without those design principles, you guys would have put in a lot of hard work and a lot of effort, but it wouldn't have really been incorporated in the final product very

> much. I think the design principles were really key to it. It boiled down all that data you collected into some real tangible things that then the engineers could wrap their minds around.
>
> (Arctic Engineer)

Ultimately, the purpose of translating social research into forms accessible to technical experts was to ensure cultural factors were incorporated into their final design, as the senior design consultant explained:

> So the translation role is important and it's going to have to be the initiative of social scientists. Or maybe there's people like us who are actually [translators]. Knowing enough to be a little bit dangerous in the social science field and enough to still be a little bit dangerous in the engineering field and trying to interpolate between those two worlds. … We didn't need to get the [technical design team] to understand culture. We needed to get the [technical design team] to understand what the impacts of culture [were] on service.
>
> (Senior Design Consultant)

The 'design principles' and the concept of 'management prototyping' were not numerical, quantitative design parameters. They did not provide 'hard' data or 'black and white' guidelines but rather were useful in encapsulating qualitative parameters such as economic, attitudinal and institutional constraints and capacities. Outside the design studio and beyond AWSC's pre-defined parameters is the social reality of managing water and sewage in remote Alaskan villages, of which these qualitative boundary conditions and cultural parameters were invaluable reminders throughout the subsequent design process.

## Evolution through transformational learning

Calls for interdisciplinary collaborations and knowledge integration to address complex twenty-first-century problems are examples of broader scale or 'macro' evolutionary pressures that encourage researchers and consultants to venture beyond their disciplinary silos and collaborate with different kinds of knowers. Perceived at a 'meso' level, the AWSC presented contradictory tendencies, on the one hand encouraging the adoption of a 'bottom up' participatory design process, but on the other reinforcing a top-down business-as-usual approach. At a 'micro' level – the focus of this section – we look at what changes team members underwent as a result of having worked on a technical design project with an unusually strong social research component.

As the project manager reflected:

> In the water sector, cross-disciplinary work is still a novelty. The collaboration provided a process for developing an integrated solution. It addressed how you integrate all that

knowledge that's quite soft and can be grey, into something tangible that you can use in designing a system.

(Project Manager)

The project led to new understandings of how a technical design could actually be improved through social research that gave team members a better appreciation of end-users' needs and capacities, compared to a technocentric approach where 'you've got a job, you go in, you build it' (Public Health Expert). The problem with the latter approach, as this team member (Arctic Engineer) explained, is that:

> after you do these projects for … 20 plus years and you do so many of them, a lot of times things start kind of blending together. Sometimes what you think is reality is really an opinion that has been formed over time and not necessarily the reality of the situation at hand.
>
> (Arctic Engineer)

Another team member echoed this point:

> So I just enjoy that type of interaction, it's so refreshing and so necessary to get a fresh look on how to solve a very old problem, which has to be done differently to how we've done it before.
>
> (Public Health Expert)

He elsewhere commented (personal communication) that through the collaboration 'we have developed design principles that would not have happened through a "normal" consultant engineering approach'.

A further sign that transdisciplinary learning had taken place was the emergent understanding that social research could do more than generate social data for technical designers to assimilate. Interpretive approaches produced different *kinds* or *modalities* of knowledge. The Arctic Engineer had thought about this and came up with the poignant analogy of a girlfriend/boyfriend relationship:

> [T]he social scientists and the engineers are kind of like a boyfriend and girlfriend relationship … everything is great, they're happy, whatever, and now it comes time that they're breaking up … They want to know why they're breaking up. Well, like the girl decides to dump the boy and the boy wants to know, 'Well, why? I mean, what did I do wrong? Did I not buy you enough things? Did I not satisfy you? Why possibly could we be breaking up?' You know, he's looking for all these kind of physical, kind of technical, whatever things. The girl just says, usually, 'Oh, it's me, it's not you. I think we just need some space' … on her side of it, it may be none of those things. It may just be a lack of emotional bond or something. … The engineer – that's the boy – is pushing to try to find

this physical … problem and it's not … it may not even be that type of problem, it may be an emotional thing.

(Arctic Engineer)

## Conclusion: conditions of knowledge production

This chapter has considered the case of a collaborative transdisciplinary project that employed some successful strategies for communicating and translating from the paradigm of interpretive social (or sociotechnical) research into terms familiar to and utilizable for water planning, but where, despite best intentions, aspirations for a participatory design process were not fulfilled. What have we learned from this case study that could help future transdisciplinary research collaborations?

Firstly, we have found the KE framework helpful for identifying who was involved and what was influencing a project, beyond the named ‘stakeholders’. It assists people to see beyond their own knowledge ‘niches’, though we cannot say whether undertaking a KE analysis at the inception of a project would smooth the way to collaboration and accelerate knowledge exchange and innovation. However, as a forensic tool, it provides a relatively neutral framework for describing the relations between different types of knowers, knowledges and conditions or environments in which knowledge is produced. In the KE model, knowledge ‘integration’ – in the positivist sense of incorporating data into some unifying knowledge field – is not presumed to be the only or most desirable relationship option.

The nitty-gritty difficulties encountered in cross-disciplinary collaborations are not often written about, in tactful avoidance of airing one's dirty linen in public. Discussing both knowers and knowledges as the equivalents of an ecosystem's ‘biotic factors’ is analytically messy, but the payoff is a relatively depersonalized way of discussing some of the difficulties encountered when trying to communicate and problem-solve across different paradigms. One might speak of members of different knowledge communities or knowledges without mentioning persons, and without presuming that one paradigm, discipline or method can make rulings about all others.

Secondly, we found that some of the problems encountered by the team could be traced back to the equivalent of ‘abiotic factors’, in the form of the AWSC brief. It expresses tendencies characteristic of positivist and techno-centric approaches to knowledge ‘integration’, where typically a bit of social research is fed into or added onto what remains primarily a technical as opposed to a socio-technical project. The AWSC Steering Committee sought project teams whose competencies mirrored its own, while its call grafted the ideas of ‘design thinking’ and ‘community engagement’ onto a standard technical design model, without actually accommodating special social research expertise, and without funding an iterative design process. The result of this pastiche was the stifling of innovation, because the design thinking logic that could have tailored decentralized sanitation solutions to particular communities was countermanded by the top-down ‘big water’ logic (Sofoulis 2005) that sought a one-size-fits-all solution based around parameters and averages predetermined by experts, and without apparent reference to real life circumstances in hundreds of remote villages in a variety of geographic and climatic zones.

Finally, the knowledge ecology framework helps us appreciate how cross-disciplinary, and in particular, cross-paradigm collaborations involve more than the assemblage of different knowers and knowledge sets: they also entail different modes of knowledge and conditions of knowledge production, and decisions (deliberate, habitual or by default) about how funds, labour and time are distributed on a project. Failures in the system to recognize differences between conditions of production for different modes of knowledge can lead to a range of problems. For example, the positivist habit of equating knowledge production with data gathering encourages an extractive approach to social research, as in the positivist social science of demographics that is familiar from census data-collection. On the basis of such assumptions, social research components are funded only enough to conduct a quick tick-box survey but not enough for a full community engagement and iterative design process.

The team members' willingness to openly and reflectively discuss their personal learning on the project afforded insights into how project resources could have been distributed differently. The need for an iterative community engagement process to calibrate the designed system to social reality is now much better understood, and it is recognized that doing this well requires a level of social research expertise and community engagement not commonly found on water planning and design projects.



## Appendix. Twelve design principles reflecting community preferences

1. Align design to user-preferred practices.
2. Keep it simple.
3. Identify where health risks are originating.
4. Design within economic constraints.
5. Design for self-sufficiency.
6. Create incentives to pay for services.
7. Design fit-for-purpose disposal/treatment.
8. Be mindful of existing revenue sources.
9. Consider full lifecycle of components.
10. Produce ‘value’ from waste stream.
11. Design for small spaces > 4 people/home.
12. Provide preferred seasonal water sources.

## Note

1 In a more committed actor-network approach, the AWSC call could be classified as an actant – a non-human actor – but here we treat it as a determinative part of the environment, an ‘abiotic factor’.

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