Dena Fam · Linda Neuhauser · Paul Gibbs
Editors

Transdisciplinary Theory, Practice and Education

The Art of Collaborative Research and Collective Learning

Springer

Transdisciplinary Theory, Practice and Education

Dena Fam • Linda Neuhauser • Paul Gibbs
Editors

Transdisciplinary Theory, Practice and Education

The Art of Collaborative Research and Collective Learning

Springer

Editors
Dena Fam
Institute for Sustainable Futures
University of Technology Sydney
Ultimo, NSW, Australia

Linda Neuhauser
School of Public Health
University of California
Berkeley, CA, USA

Paul Gibbs
Centre for Education Research and Scholarship
School of Health and Education
Middlesex University
London, UK

ISBN 978-3-319-93742-7   ISBN 978-3-319-93743-4 (eBook)
https://doi.org/10.1007/978-3-319-93743-4

Library of Congress Control Number: 2018950455

This Springer imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Transdisciplinary Theory, Practice and Education: The Art of Collaborative Research and Collective Learning is a timely publication. It calls on academics, practitioners, community members and students to jointly navigate the interstices of traditional scientific knowledge and societal knowledge as a means to more effectively deal with our planet's most pressing issues. Complexity and persistent global problems such as the poverty, social inequity, climate change impacts and economic crises that plague both developed and developing countries today will not be solved through siloed disciplinary thinking alone. As both the editors and authors of this book have proposed, a transdisciplinary focus that draws from various disciplinary practices but is blind to the boundaries between them, and seeks contributions and partnership with a range of different perspectives and stakeholders (from both the public and private sectors), is needed.

The importance of different perspectives is demonstrated in the contents page, which highlights the breadth of international contributors to this book. These include many of the leading thinkers and institutes in transdisciplinary research, practice and education worldwide. These contributors have not only added to the theoretical development and discourse on transdisciplinarity, but have also helped inspire innovation at the University of Technology Sydney (UTS), where educational programmes have been developed to integrate disciplinary knowledge through practice-based and problem-focused learning at both the undergraduate and postgraduate levels. The new Faculty of Transdisciplinary Innovation at UTS (2016) serves as a marker of our view of the centrality of transdisciplinary approaches to future skill development and problem solving for society. The faculty continues to build upon the work of many of the contributing authors who have paved the way for the development and evolution of transdisciplinary thinking.

I applaud and thank the editors for bringing together such a broad network of collaborators. This not only brings to light the range of intercultural endeavours taking place in China, the USA, France, the UK, Switzerland and Australia, but also importantly brings to the fore the rich and valuable contribution Indigenous knowledge and local community perspectives make to collaborative research endeavours. A key characteristic of many of the contributions in this book is the conceptual shift from producing ‘science for society’ to ‘science with society’. The important recognition that working in partnership with societal actors (researchers, citizens, policy makers, business, industry, etc.) across the research, innovation and implementation processes aligns the outcomes of research with the values, needs and expectations of those impacted by that research.

What the contributors to this collection of transdisciplinary case studies, theoretical reflections and educational programmes are proposing is a new paradigm of research and practice for finding solutions to global challenges. It is an approach in which collaborative research, collective learning and active stakeholder engagement are core rather than peripheral elements. By providing exemplary cases of transdisciplinarity in practice, this book is in effect an inspiration for others to step beyond the boundaries and experiment, to embrace participatory processes and relational thinking to more effectively create a more sustainable and equitable future.

University of Technology Sydney Attila Brungs
Ultimo, NSW, Australia
Institute for Sustainable Futures, University of Technology Sydney Dena Fam
Ultimo, NSW, Australia

Endorsement

Interested in transdisciplinarity? Want to improve your teaching and research? This book is packed with useful lessons. Whether you want a stronger theoretical grounding, insights into how peers approach teaching of transdisciplinarity, or transdisciplinary research case studies, this book offers a range of imaginative approaches.

Dena Fam, Linda Neuhauser and Paul Gibbs have done a superb job of pulling together contributions from 46 authors presenting diverse teaching and research examples from around the world. They lift the lid on this important topic – one that will only grow in significance as research and education organizations embrace the challenges of supporting researchers and preparing students to deal with the myriad complex social and environmental problems the world is confronting.

Gabriele Bammer,
Professor of Integration and Implementation Sciences,
The Australian National University

With their new book, *Transdisciplinary Theory, Practice and Education: The Art of Collaborative Research and Collective Learning*, Fam, Neuhauser and Gibbs supply a valuable resource for all those interested in transdisciplinary research. Adopting an international perspective, the editors recognize the importance of thinking about transdisciplinarity broadly. This emphasis on breadth is reflected in the book's helpful structure, which combines the perspectives of theorists, educational experts and transdisciplinary practitioners from around the world. Theorists will profit from the first part, which contains a wide-ranging set of chapters that supply conceptual clarification, a history of transdisciplinarity, and discussions of the nature and reach of transdisciplinary thinking and learning. The second part is especially valuable – it contains a number of insightful contributions that address the need for more systematic and practical discussion of transdisciplinary education. Finally, the third part presents several detailed case studies that address transdisciplinary integration challenges in a number of contexts, including those of

Indigenous worlds, the spaces occupied by migrant factory workers, and art/science collaborations. All in all, this book should be of significant value for anyone engaged in transdisciplinary practice, including researchers, teachers and community partners.

Professor Michael O'Rourke,
Department of Philosophy Faculty,
Michigan State University

In the face of current public and environmental problems, which are often not just complex but also 'wicked' (meaning that they defy a definitive solution as each attempt to solve them implies that some elements are foregrounded whilst others necessarily neglected) academic and extra-academic experts and stakeholders feel an urgency to join forces. Recognizing that disciplinary specializations can yield deep knowledge of isolated elements yet is incapable of comprehending the complex and dynamic systems in which such elements figure, working alone risks missing the problem. Such collaborations are necessary for developing solutions that work not just in computer simulations or laboratoria but also in the messy world where natural processes unexpectedly change their course and people can behave in meaningful yet nonetheless surprising ways. To reach that goal, not just interdisciplinary but novel *transdisciplinary* methods of research are required that integrate not just different disciplines but also extra-academic perspectives. Students must familiarize themselves with these methods, which are also linked to novel approaches like action research, participatory research and design science. Particularly given a shared awareness that this task cannot be performed by experts in isolation, this creates what I have called elsewhere a paradox of our education: Can we prepare our university students for life in such future hybrid academic and non-academic environments?

Bearing this background in mind, this very rich volume is indeed a very timely book: it makes fresh connections between geographically and methodologically distinct approaches to transdisciplinary research, and it offers convincing examples of applying such transdisciplinary research in an educational setting, while also reflecting on the challenges, risks and benefits of this endeavour. For it is by no means a modest task for experts, for students or for extra-academic stakeholders, to share each other's experiences, ideas, interests and norms regarding the complex problem that brings them together. Indeed, seeking a joint solution for this requires that they co-develop the whole process, including the determination of what actually the problem is – whilst all along reflecting upon and articulating their different normative and socio-cultural positions that might impede this process.

Such a transdisciplinary research has been developed particularly in the context of sustainability and public health problems, yet this volume also demonstrates its viability in other domains, including the arts and social sciences. Indeed, upon reading this very well-composed collection, the reader is invited to reflect not just about disciplines and problems but to engage in reflection upon what it is to live, work and think together on our planet.

Reflective equilibrium is an integrative and normatively conscious process that could help to jointly discuss the methodological and theoretical pluralism offered here, and co-decide about our attentive actions upon balancing this pluralism against the principles and norms relevant for the problems and ourselves.

Dr. Machiel Keestra,
Institute for Interdisciplinary Studies (IIS),
University of Amsterdam

I thoroughly enjoyed *Transdisciplinary Theory, Practice and Education: The Art of Collaborative Research and Collective Learning* edited by Dena Fam, Linda Neuhauser and Paul Gibbs. I have been interested in learning more about how researchers and teachers were integrating TD in pedagogy in different educational contexts around the world. This book covers just that. It gives an overview of different ways of doing TD research and teaching in Australia, China, Switzerland, the USA and the UK. It also offers a broad theoretical discussion which brings together diverse discourses that have not always spoken to one another or taken advantage of parallel trains of intellectual development in diverse fields such as collaborative learning, design theory, innovation approaches and systems theory, to name but a few. Different case studies also include a variety of concrete methods and ways of working together that promote different examples of boundary breaking collaboration, such as communities of practice, design competitions, field trips and living labs. The chapters that dealt with different types of transdisciplinary pedagogy within university settings were inspiring. The chapters that discussed more open change processes in problem-solving contexts that extended beyond the university also opened my mind to new possibilities when working across different cultural and intellectual divides.

This book raises some challenging questions. For example, what role can TD pedagogy have in present day university systems? How can TD approaches to learning and teaching contribute to present day sustainability challenges? What are the institutional barriers to such pedagogy? In some of the more ideologically based chapters, I also found myself provoked and inspired by metaphorical writing which suggest other positions and possibilities for research and education based on individual values, self-knowledge, feelings and being. While multiple epistemologies and ontologies are gaining ground in many subject areas as the basis for more effective ways of dealing with present day sustainability challenges, such approaches sometimes contest the very foundations of what research and education have traditionally stood for. This forced me to ask myself an unfamiliar question, namely can one go too far in opening up to different claims to knowledge and still call oneself a researcher and/or educator? What quality standards should or could we apply to TD research and education? I will be returning to this book, and its innumerable ideas, arguments, concrete examples and references that deserve further thought and consideration.

Dr Merritt Polk
School of Global Studies
University of Gothenburg

Contents

Contributors

Carolina Adler (née Roman), an environmental scientist and geographer, has a career spanning both research and practice in the public and private sectors. She obtained her PhD at Monash University (Australia) in 2010, focusing on climate change adaptation in mountain regions. The relevance and significance of her work to policy led to an invitation to join the Society for Policy Scientists. She served as Vice President in its Executive Council. She was awarded with the 2010 Harold D. Lasswell Prize for best dissertation in public policy. She is a Research Fellow at the Environmental Philosophy Group and Transdisciplinarity Lab (TdLab) at ETH Zurich in Switzerland. She is also Executive Director of the Mountain Research Initiative, an organization hosted by the Swiss Academies of Sciences. In this role, she is tasked with coordinating scientific research and networks on global change in mountains.

Sono Aibe Master of Health Science (MHS), is Senior Advisor for Strategic Initiatives at Pathfinder International. She works closely with Pathfinder's executive leadership to strategize and expand Pathfinder's sexual and reproductive health programme development and design, especially in the Asia region. She is also advancing Pathfinder's global and field advocacy strategies, serving as the technical lead for integrated reproductive health and environmental conservation programmes in East Africa, and developing new partnerships worldwide. She holds degrees from Harvard University and Johns Hopkins Bloomberg School of Public Health.

Keith Armstrong's engaged, participative practices have long provoked audiences to comprehend, imagine and envisage collective pathways towards sustainable futures. He has exhibited widely in major international new media festivals, biennials and galleries and has produced major commissions at the Powerhouse Museum, the Queensland Museum, the China Science and Technology Museum, Beijing, and Media Art China amongst many others.

Craig Ashhurst's background is diverse, with time spent as a bookseller, youth worker, teacher, developer of educational software and management consultant. Teaching and learning have been a central thread linking his various roles. Craig has taught from kindergarten to the postgraduate level and holds multiple qualifications in education. His master's thesis was a study on 'wicked problems', those complex social problems with multiple stakeholders. Since 2013 he has been working on his PhD, titled 'One-Team – Where Worlds Collide'. His thesis explores collisions of worldviews in developing policy related to wicked problems. He is based in the Fenner School at the Australian National University and his research is being conducted in association with the Federal Attorney General's Department. Craig formed his own company in 1995 and has worked in both the private and public sectors, mostly with large organizations or departments. His company, Niche Thinking Pty Ltd, has done consultancy work with a focus on innovation, strategic thinking, facilitation, design and translation across a range of disciplines. He has specialized in facilitating the thinking of diverse groups of stakeholders facing complex problems.

Sarah Barns is an urban researcher, digital producer and strategist whose work focuses on place-making and the disruptive potential of digital transformation in cities. Her work spans industry innovation, place-making and smart cities. She delivers advisory, design strategy and consulting services to a range of government and private sector clients. Sarah was awarded a UK Urban Studies Foundation Postdoctoral Research Fellowship in 2013 through Western Sydney University to address the urban governance and policy implications of data-driven methodologies for strategic planning and civic participation. The fellowship involved residencies in New York and London addressing the use of urban science in local governance contexts. She has led the digital place-making studio Esem Projects since 2010 and has a passion for the role of place and urban design in fostering connected and resilient communities.

Valerie A. Brown AO, BSc, MEd, PhD, is currently Professorial Fellow and Director, Local Sustainability Project, at the Fenner School of Environment and Society, Australian National University. She is Emeritus Professor of the University of Western Sydney and was its Foundation Chair of Environmental Health 1996–2002. The Local Sustainability Project is a collective action research programme working in Australia and internationally with organizations, local government and communities on whole-of-community change 1989–2016. Her recent books are *The Human Capacity for Transformational Change* (with John Harris, Routledge 2014); *Tackling Wicked Problems Through the Transdisciplinary Imagination* (also with John Harris, Earthscan 2010); *Collective Learning for Transformational Change* (with Judith Lambert, Routledge 2013); *Sustainability and Health* (with John Grootjans et al., Allen and Unwin 2005); and *Social Learning and Environmental Management* (with Meg Keen and Robert Dyball, Earthscan 2005). Her website is www.valeriebrown.com.au

Michelle Callen has a diverse communications background spanning publishing, politics and currently higher education. Being the first in her family to benefit from a university education instilled a belief in the transformative power of education and the importance of a quality, accessible and equitable higher education system. Working at the University of Technology Sydney has provided an insight into creating an educational experience that truly equips graduates with the skills needed for their future careers, whatever they may be. Involvement in a project to help develop interdisciplinary courses sparked a determination to understand and articulate the difference between interdisciplinary and transdisciplinary education. The project has become an ongoing pathway to identifying and tackling institutional barriers to enabling cross-disciplinary, interdisciplinary and transdisciplinary learning, research and collaboration.

Anthony Capon is the inaugural Professor of Planetary Health at the University of Sydney. A former director of the global health institute at United Nations University (UNU-IIGH), Tony is a public health physician and authority on environmental health and health promotion. For more than 20 years, he has been leading transdisciplinary research and capacity building efforts on the broad theme of urbanization, sustainable development and human health. Since 2008, he has advised the International Council for Science (ICSU) on their global interdisciplinary science programme on health and well-being in the changing urban environment using systems approaches. Tony is a member of The Rockefeller Foundation–*Lancet* Commission on Planetary Health which published its report ‘Safeguarding Human Health in the Anthropocene Epoch’ in 2015. He has served in numerous honorary leadership roles with professional and not-for-profit organizations including the International Society for Urban Health and the Frank Fenner Foundation.

Elizabeth Clarke is a transdisciplinary researcher and practitioner with interests spanning complex integrated systems, sustainability science, research–policy engagement in development and knowledge management. She has a background in natural resource and rural systems research and development. She is a Research Fellow in the Leverage Points for Sustainability Transformation Project at Leuphana University’s Institute for Ethics, Transdisciplinarity and Sustainability in Germany, as well as Lecturer at the Fenner School of Environment and Society at the Australian National University, where she teaches society and environmental change, sustainable rural systems, and research methods, design and practice. She has extensive experience in international research for development and has worked in senior roles with the Consultative Group for International Agricultural Research (CGIAR). These roles have been with the Consortium of the International Agricultural Research Centres, the International Center for Agricultural Research in the Dry Areas (ICARDA) and WorldFish. Prior to that, she worked with the Australian Centre for International Agricultural Research (ACIAR) in knowledge management, communications, research management, government liaison and governance.

Alexandra Crosby is the Director of Interdisciplinary Design at the University of Technology Sydney. She studied Visual Communications and International Studies, completing her PhD in 2013 on local environmentalism enacted through site-based creative community events in contemporary Indonesia. She has worked extensively on cross-cultural projects in Australia and the Asia-Pacific region. She develops and uses interdisciplinary research methods, such as hybrid forms of mapping and participatory futuring, to understand the complexity of current situations and communicate possible futures. She is part of the Mapping Edges research studio.

Ian Cunningham is an environmental engineer and researcher who works at the intersection of engineering, appropriate technology and social change. His practitioner experience has predominantly been within the civil society and tertiary education sectors. His work has included the design of programmes in Australia which integrate traditional knowledge and Western science, and programmes in South and South-East Asia which involve working with grassroots organizations in the areas of energy, education, water supply and sanitation. Currently, he is a PhD researcher with the Institute for Sustainable Futures at the University of Technology Sydney, exploring the role of strength-based approaches in citizen-led rural water supply in the Asia-Pacific region.

Carole M. Cusack is Professor of Religious Studies at the University of Sydney. She trained as a medievalist and her doctorate was published as *Conversion Among the Germanic Peoples* (Cassell 1998). She researches and teaches on contemporary religious trends (pilgrimage and tourism, modern pagan religions, new religious movements, and religion and popular culture). Her books include *Invented Religions: Imagination, Fiction and Faith* (Ashgate 2010), *The Sacred Tree: Ancient and Medieval Manifestations* (Cambridge Scholars 2011), and (with Katharine Buljan) *Anime, Religion, and Spirituality: Profane and Sacred Worlds in Contemporary Japan* (Equinox 2014). She has published widely in edited volumes and journals and is the editor (with Alex Norman) of *Handbook of New Religions and Cultural Production* (Brill 2012) and (with Pavol Kosnáč) *Fiction, Invention and Hyperreality: From Popular Culture to Religion* (Routledge 2017). With Rachelle Scott (University of Tennessee, Knoxville) she is editor of *Fieldwork in Religion* (Equinox).

Jason De Santolo (Garrwa & Barunggam) is a researcher, creative producer and father committed to forging a sustainable world for future generations through transformative research strategies, storytelling and practices of renewal. He is currently a Senior Researcher at Jumbunna Institute at the University of Technology Sydney. Born in Larrakia homelands – Darwin, his tribal affiliations are Garrwa and Barunggam. He moved to Aoteaoroa/NZ at an early age, growing up to eventually study treaty and international environmental law. His unique research practice integrates video, creative practice and renewal strategies through a Garrwa-driven decolonizing research paradigm. In 2014, he received a UTS Research Excellence

Scholarship to undertake a creative doctorate that explores the renewal of song traditions through his passion for filmmaking and collective aspirations for self-determination and sustainable autonomy.

Suzanne Dunford is a Principal Project Officer at the NSW Office of Environment and Heritage. She has been working in the field of climate change since 1998 in a variety of state government agencies and roles, in diverse areas including renewable energy, energy efficiency, planning policy, urban greening, community resilience, climate change and communications. Most recently, her work has focused on how systems and communities adapt to climate impacts and on developing tools and resources that build adaptive capacity in NSW.

Dena Fam is a system 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 has spanned the socio-cultural (learning for sustainability), institutional (policy analysis) and technological aspects of environmental management. With experience in transdisciplinary project development, Dena has increasingly been involved in developing processes for teaching and learning in transdisciplinary programmes and projects. In particular, she has been involved in documenting and synthesizing processes/methods/techniques supporting the development of transdisciplinary educational programmes and projects. Dena has led and co-led international transdisciplinary networking events, grants and projects, including an Australian-funded teaching and learning grant.

Paul Gibbs is Director of Education Research at the University of Middlesex. He is a professor of the university, founder of the Centre for Education Research and Scholarship and an Honorary Research Fellow at the Open University in Hong Kong and the University of Cyprus. In 2017, he published three books: *Why Universities Should Seek Happiness and Contentment*; *The Pedagogy of Compassion at the Heart of Higher Education*; and *Transdisciplinary Higher Education: A Theoretical Basis Revealed in Practice*. He is also series editor of two series of books for Springer Academic Press: ‘SpringerBriefs on Key Thinkers in Education’ and ‘Debating Higher Education: Philosophical Perspectives’. He writes on the marketing of higher education.

Tanja Golja PhD, is a researcher in design education and educational design at the University of Technology Sydney. She has a special interest in understanding the design of principled transdisciplinary learning environments and theoretically sound educational development. As Head of Transdisciplinary Education Innovation, she is leading the educational design and development of a suite of cutting-edge transdisciplinary programmes (including the award-winning Bachelor of Creative Intelligence and Innovation, the Master of Data Science and Innovation, the Bachelor of Technology and Innovation and the Graduate Certificate in Transdisciplinary Learning), in collaboration with industry and multidisciplinary academic teams.

Lesley Hitchens is Professor of Law at University of Technology Sydney and, since 2013, Dean of the Faculty of Law. She practised as a lawyer in Australia and London and has held academic appointments at English and Australian universities. Her main research area is media and communications regulation, with a particular focus on the relationship between media policy and regulation, and, more recently, the impact of new media on traditional regulatory approaches. Her research also has a comparative focus, concentrating on Australia, the UK (and the EU) and the USA.

Yun Hong is Secretary-General of the Changzhou Family Planning Association, China. Her practice is focused on community health promotion.

Brent Jacobs is a Research Director working in natural resources and climate change adaptation at the Institute for Sustainable Futures at the University of Technology Sydney. Brent's background is in agricultural science. He has gained broad experience in agricultural systems and ecophysiology through teaching and research in universities in Australia and internationally. Brent has worked in the areas of natural resource management, structural adjustment and development of assistance packages to accompany natural resource reforms for the NSW Government. His current research interests include the development of integrated techniques to assess the resilience, vulnerability and adaptive capacity of communities in the development of climate adaptation strategies. Brent leads the Adaptive Communities Node of the NSW Government's Climate Adaptation Research Hub. In quieter moments, he contemplates how an agronomist came to be doing transdisciplinary research on bus shelter design.

Krista Jordan is a Development Manager for 'Animal Logic'. She has worked in the digital film, advertising and television industry for over 20 years. After completing a Bachelor of Visual Communication at the University of Technology Sydney, she began her career working on commercials for clients including Qantas, Lexus, Kelloggs and Visa. Her feature film credits include *Babe*, *Moulin Rouge*, *The Matrix*, *Matrix: Reloaded*, *The Thin Red Line*, *Hero* and *Happy Feet*. Later in her career her interest in the human component of creative practice inspired her to move into the areas of human resources and learning and development. Previous roles include creative and technical recruiter and Head of Recruiting and Human Resources (Flying Bark Productions).

Scott Kelly is a Research Director at the Institute for Sustainable Futures. He is an interdisciplinary researcher with qualifications in both natural and social sciences. He has taught and practised within the disciplines of engineering, economics, risk analysis, sustainable development and climate change policy. Scott has a passion for using computational methods and data analytics for modelling complex real-world problems. He has held academic appointments at both British and Australian Universities. Scott received his Ph.D. in 2013 and in 2015 was elected as a Junior Research Fellow of Darwin College. He holds research affiliations with the Cambridge Centre for Risk Studies and the Energy Policy Research Group at the University of Cambridge. He has published over a dozen peer-reviewed journal articles and multiple book chapters covering subjects such as energy systems, economics, catastrophe modelling, climate change policy and sustainable development.

Julie Thompson Klein is Professor of Humanities Emerita at Wayne State University in Detroit. 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. She has a PhD in English from the University of Oregon, and is past president of the Association for Interdisciplinary Studies (AIS), a former editor of the Association of Interdisciplinary Studies Journal *Issues in Interdisciplinary Studies*, and a recipient of the Kenneth Boulding Award for outstanding scholarship on interdisciplinarity. Her books include *Interdisciplinarity* (1990); *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 associate editor of the *Oxford Handbook on Interdisciplinarity* (2010, 2016) and co-editor of the University of Michigan Press series: *Digital Humanities@digitalculturebooks*.

Pius Krütli is senior scientist and co-director of the Transdisciplinarity Lab (TdLab) of the Department of Environmental Systems Science at ETH Zurich (www.tdlab.usys.ethz.ch). He studied environmental sciences at ETH Zurich. His PhD was about repository siting for nuclear waste with a special focus on justice. Pius has widened his justice-related research in recent years to other topics like medicine and sustainability. Justice is an important consideration in sustainability, and it has become a focus of his research and teaching activities. Transdisciplinarity is a major vehicle and approach in all these activities.

Eve Wen-Jing Lee MA, is Special Advisor for Asian Projects at the Health Research for Action Center, School of Public Health, University of California, Berkeley (USA). She has long been an advocate for women's health issues, reproductive health and rights. She was a Programme Officer of the Ford Foundation's China office for 9 years, and her work included designing, managing, developing, monitoring and evaluating programmes in the fields of sexuality, reproductive health and rights in China and the Asia region. She was also a Senior Consultant for Pathfinder International and the Population Council, and Vice President of the Public Media

Center, a public interest advocacy and communication agency providing technical assistance and institutional capacity for China's NGOs.

Tania Leimbach teaches in the Design Architecture and Building, School of Design and the Faculty of Social Science, School of Communication at the University of Technology Sydney. She has worked in exhibition design, curating and collections management for public and private galleries, and has professional experience in visual art and design education across a range of learning environments, including museums, secondary schools and tertiary education. Her current research involves a review of sustainability in the tertiary sector and developments in the integration of sustainability into tertiary curricula across disciplines and diverse learning contexts.

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 programme 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'.

Kate Maguire is an Associate Professor in the Faculty of Professional and Social Sciences at Middlesex University, London, and Director of its transdisciplinary doctoral programmes. Her background is in social anthropology of the Middle East, trauma psychotherapy and authority dynamics. Since coming into higher education, she has engaged in developing innovative research pedagogies and methodologies relevant to professional practice. She has delivered papers on transdisciplinarity, aligning it to anthropology and examining its relevance to the contemporary pursuit of answers to complex micro and macro problems. She was drawn to professional practice research for the same reasons she remains informed by anthropology: to focus on the interconnectedness of knowledges rather than their separation. Co-generated knowledge has a role in creating the conditions for a more equitable share in decision-making processes to improve the societies in which we live.

Jingsu Mao MD, is Professor in the School of Humanities and Social Sciences at Nanjing Youdian University, China. She is also Director of the Department of Public Management at Nanjing Youdian University's School of Humanities and Social Sciences. Her teaching, research and practice are focused on studies of population and maternal and child health in China.

Shilo McClean PhD, is the author of the books: *The Digital Playing Fields: New Rulz for Film, Art and Performance* (Currency House, July 2010), *Digital Storytelling: The Narrative Power of Visual Effects in Film* (MIT Press, 2007, 2008, 2009) and *So What's This All About Then: A Non-user's Guide for Digital Effects in Film* (AFTRS 1998). She was a consultant to Animal Logic on the production of their *Art of the Legend of the Guardians* book (2012) and was the University of Technology Sydney (UTS) producer of *Data Arena Showreel*, a 360° 3D stereoscopic computer-generated immersive film by Animal Logic released in 2015. The Data Arena Showreel continues to screen in UTS' bespoke Data Arena screening space. Currently, Professor McClean is Head of the UTS Animal Logic Academy and Chair of the Sydney ACM SIGGRAPH Professional Chapter.

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 programme. 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 Technological Sciences and Engineering, a fellow of Engineers Australia and a fellow of the Institute of Community Directors of Australia.

Linda Neuhauser is Clinical Professor of Community Health Sciences at the School of Public Health, University of California, Berkeley (USA), and is Visiting Professor in the Department of Social and Population Sciences at Nanjing Youdian University (Nanjing, China). She is also Co-Principal Investigator of the Health Research for Action Center (HRA) at the UC Berkeley School of Public Health. Her teaching, research and practice are focused on using participatory methods across disciplines and societal sectors to engage diverse groups to identify and solve problems. She and her colleagues have used participatory and transdisciplinary methods to co-create, co-implement and co-evaluate health and social interventions in many countries.

Basarab Nicolescu is an honorary theoretical physicist at the Centre National De La Recherche Scientifique (CNRS). He is a professor at the Babeş-Bolyai University in Romania and at Stellenbosch University, South Africa. He is a member of the Romanian Academy and president and founder of the International Center for Transdisciplinary Research and Studies (CIRET). His publications include *Science, Meaning and Evolution: The Cosmology of Transdisciplinary* and *From Modernity to Cosmodernity*. His most recent book, *The Hidden Third*, is the English translation of *Théorèmes Poetètiques*. He has lived in France since 1968.

BinBin Pearce is a lecturer, curriculum developer, and researcher at ETH Zurich in the Department of Environmental Systems Science. Her focus is on developing tools and methods that foster students' ability to perceive and resolve complexity in the real world with clarity and creativity. She is a part of the teaching team for a year-long course for first-year bachelor students, 'Umweltproblemlösen' (Environmental Problem Solving) and for a masters-level course called 'Transdisciplinary case study'. She is also the coordinator and coach for the Transdisciplinarity Lab Winter School 'Science meets Practice', a week-long training programme which aims to enable PhD students from all disciplines to see how perspectives in research can be interpreted for societal needs. She completed her bachelor's and master's study in environmental engineering at Stanford University and obtained her PhD from the Yale University School of Forestry and Environmental Studies.

Christian Pohl with a PhD in environmental sciences and a habilitation degree from the University of Bern, is co-director of the Transdisciplinarity Lab of the Department of Environmental Systems Science at ETH Zurich (www.tdlab.usys.ethz.ch). TdLab is in charge of the department's transdisciplinary case study teaching. Christian Pohl studied environmental science, followed by a doctoral thesis on uncertainty in environmental assessments. As a postdoc, he moved to the field of science studies and analysed interdisciplinary and transdisciplinary research. Over the last decade he has contributed to the development of the theory and practice of transdisciplinary research, specifically in the field of sustainable development (cf. *Principles for Designing Transdisciplinary Research*, *Handbook of Transdisciplinary Research*, and *Methods for Transdisciplinary Research*). Together with td-net of the Swiss Academies of Arts and Sciences, he has developed a compilation of methods for coproducing knowledge.

Jason Prior is a Research Director at the Institute for Sustainable Futures at the University of Technology Sydney. As an architect, planner, urban sociologist and legal geographer, Jason's programme of transdisciplinary research focuses on processes of spatial governance across a range of disciplines including law, architecture, property rights, planning and environmental management. Whilst at ISF Jason has led over 20 research projects on spatial governance in relation to sexuality, religion, health and well-being, and environmental risk amongst other topics, with a particular focus on how spatial governance influences issues of equity, vulnerability and resilience. His research has been carried out in Australia, France, Italy, the People's Republic of China, the USA, Canada and the UK, and arises through collaboration with national and international research institutions, government, industry, communities and the spatial professions. Jason's research has been published widely in a diverse range of journals including *Urban Studies*, *Environment and Planning A*, *Journal of Sex Research*, *Urban Policy and Research*, *Critical Social Policy*, and the *Journal of Cleaner Production*. He recently completed a four-volume collection with Professor Carole Cusack (The University of Sydney) titled *Religion, Sexuality and Spirituality: Critical Concepts in Religious Studies* (Routledge, 2016). See: https://m.uts.edu.au/staff/jason.prior

Chris Riedy is the Director of Higher Degree Research at the Institute for Sustainable Futures at the 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 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.

Jochen Schweitzer teaches Strategy, Innovation and Entrepreneurship and is the Director of the MBA Entrepreneurship at the University of Technology Sydney's Business School. He is also Founder/Director of U.lab, a multidisciplinary innovation hub. Previously, he has worked as a design thinking coach, management consultant, production-planning engineer and cultural programme coordinator. His research, teaching and consulting focuses on issues of strategy, collaboration, entrepreneurship and innovation with a special interest in design thinking, urban planning and open innovation. Jochen seeks to expand the capacity of strategy and design into truly interdisciplinary and open opportunities for innovation and entrepreneurship. He collaborates broadly and his work has been recognized internationally and published in academic journals and books.

Lisette Senn worked for 11 years as a primary school teacher in Switzerland (in the canton of Baselland). For 2 years she was a coach for pedagogical students to help with strengthening practical teaching skills in the classroom. Lisette studied environmental sciences at ETH Zurich and obtained a master's degree in ecology and evolution within the Department of Environmental Systems Science (D-USYS) in

2012. She has also worked as a scientific assistant and officer at Agroscope, the Switzerland's research institute for agricultural sciences and biodiversity. Since January 2013 she has been responsible for organizing a case study course (Introduction to Environmental Engagement) for first-year bachelor's students in D-USYS. Since the fall of 2016, this course has been re-launched as 'Environmental Problem Solving'.

Xingyu Shu PHD, MPH, is Assistant Professor in the School of Humanities and Social Sciences at Nanjing Youdian University, China. He is also a researcher at the Institute of Population and Health at Nanjing Youdian University. His teaching, research and practice are focused on population programme management and public health in China.

Michael Stauffacher has a PhD in sociology and is a professor at ETH Zürich. He is co-director of the Transdisciplinarity Lab of the Department of Environmental Systems Science at ETH Zürich. He has been teaching and researching for more than 20 years at ETH Zürich, has been a guest researcher at the Potsdam Institute for Climate Impact Research (PIK) and at Lancaster University (UK), and has had teaching appointments at Stellenbosch University (SA) and Leuphana University of Lüneburg. He serves as President of the Swiss Academic Society for Environmental Research-SAGUF and is a member of the Board of Directors of the Swiss Academy of Humanities and Social Sciences-SAGW. In his teaching, he is interested in project-based, student-centred and research-oriented learning. His teaching is problem-oriented and interdisciplinary. Close interaction with societal actors is of key importance, both in developing teaching courses and in running the course. For a full CV, teaching activities and list of publications, see http://www.tdlab.usys.ethz.ch/people/person-detail.html?persid=79110

Xiaoming Sun MD, MS, is Professor in the School of Humanities and Social Sciences at Nanjing Youdian University, China. He is also Director of the Institute of Population and Health at Nanjing Youdian University. His teaching, research and practice are focused on population health and evaluating the quality of services of family planning and reproductive health in China.

Lee Wallace is a Design and Policy Officer with the Australian Government. She has been working in the field of sustainability since 1994 in a variety of federal government agencies and roles, in diverse areas including forestry, marine moorings, natural resource management, tourism, sustainable housing and energy efficiency. Recently, she has conducted research focusing on how innovation disrupts systems and community responses, and on using tools, such as Human-Centred Design, to engage communities in the co-design of solutions.

Xiaodong Wang MD, is Deputy Director of Changzhou Health and Family Planning Commission, China. His practice is focused on population development, reproductive health and family planning management in Changzhou city.

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 making contributions to gender equality, sustainability, civil society's 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 programme at the Institute for Sustainable Futures at the 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 University of Technology Sydney awards for research excellence, human rights and social justice, and was a finalist in the 2014 National Australia Bank's Women's Leadership awards.

Zhanhong Zong PHD, MPH, is Associate Professor of the School of Economics at Nanjing Youdian University, China. She is also a researcher at the Institute of Population and Health at Nanjing Youdian University. Her teaching, research and practice are focused on population statistics and young migrants' living and health status in China.

List of Figures

List of Tables

Part I
Theorising Transdisciplinarity As a Collaborative Practice

Chapter 1
Introduction – The Art of Collaborative Research and Collective Learning: Transdisciplinary Theory, Practice and Education

Paul Gibbs, Linda Neuhauser, and Dena Fam

This book embraces an ecology of uncertainty, unfairness, complexity, and lack of agency. It weaves a fabric of solution, respect and agency in the sphere of collective transdisciplinary endeavour. The authors believe that transdisciplinary and interdisciplinary approaches to research and education are critical for addressing complex problems involving multiple disciplines and a diversity of societal actors in real-life contexts. The underlying assumption is that creating effective solutions to complex problems requires exchanging knowledge and experiences among a diversity of disciplines (across the social and natural sciences and the arts) with stakeholders in both public and private spheres (Gibbons et al. 1994; Lang et al. 2012; Neuhauser and Pohl 2014; Westberg and Polk 2016; Robinson 2008; Fam et al. 2017; Gibbs 2015).

1.1 The Emergence of Transdisciplinarity to Address Complex Problems

The transdisciplinary movement was directly catalyzed by the practical challenges of addressing complex problems in society. Researchers, practitioners and policy-makers have long critiqued the disappointing results of efforts to create and implement research that benefits society. Since the mid-twentieth century, there has

P. Gibbs (✉)
Centre for Education Research and Scholarship, School of Health and Education, Middlesex University, London, UK
e-mail: P.Gibbs@mdx.ac.uk

L. Neuhauser
School of Public Health, University of California, Berkeley, CA, USA

D. Fam
Institute for Sustainable Futures, University of Technology Sydney, Ultimo, NSW, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_1

been a strong focus on the challenge of addressing highly complex and seemingly intractable problems. Stakeholders external to academia (in industry, government and community) have identified major deficiencies in traditional research approaches related to: (1) research integration; (2) research translation and implementation; and (3) participatory processes.

In an ideal world, researchers and stakeholders who implement research would have access to knowledge from many disciplines. However, in reality, most researchers work primarily in a limited number of disciplines and in institutions in which knowledge is increasingly becoming specialized into sub-disciplines (Bammer 2003; Lubchenco 1998). Typically, research studies do not go deeply or broadly enough into the fundamental determinants of problems (Phelan et al. 2010). As a result, many interventions only have a weak impact.

Since the end of the twentieth century, the "social-ecological model" (Stokols 2006) has become a widely used framework to guide researchers, practitioners and policymakers in translating scientific findings to effective interventions. This model demonstrates that interacting with levels of society ranging from individuals, families, neighbourhoods/communities, and organizations to the broadest cultural, political, environmental levels is required to influence change. Those who research problems and/or those who develop and implement interventions are urged to take into account each of these levels and their interactions.

By the late twentieth century, models of research "translation" or "dissemination" had emerged as a way to fill the knowledge–action gap. Knowledge dissemination can be defined as "an active and strategically planned process whereby new or existing knowledge, interventions, or practices are spread" (Kiefer et al. 2005: I–14). As with first generation research integration models, the early research translation/dissemination models assumed the existence of a two-step process in which researchers would conduct research and then professionals would implement it. This disconnected approach, and its frequently unsuccessful results, were widely critiqued—motivating a move towards transdisciplinary models, as described in this book. Knowledge should not only be integrated across disciplines; it should also be implemented across societal sectors. Unfortunately, even researchers who incorporate multiple disciplinary perspectives may overlook the need to deeply engage with beneficiaries and stakeholders across sectors (Neuhauser et al. 2007). As a result, there is ample evidence that even when we have excellent evidence-based research that addresses the main determinants of a problem, we may not be able to translate that knowledge into practical strategies that people can adopt in their social contexts. Jensen (2003) estimated that interventions rarely reach more than 1% of the target population.

1.2 How the Book Addresses These Issues

While transdiscipinarity (TD) has had over 40 years of extensive scholarly discourse, there is no single, universally accepted definition of TD (Jahn et al. 2012). This is because TD is an approach, not a theory or method, but as Jahn et al. (2012)

reveal, there are common characteristics associated with TD approaches. Transdisciplinary inquiry aims to move beyond disciplinary boundaries in solving complex problems (Robinson 2008). Wickson et al. (2006) go even further to suggest three primary characteristics of transdisciplinary research: (1) it is problem focused, (2) it has an evolving methodology and (3) it is highly collaborative and participatory. Just as there is no one definition of transdisciplinarity, there are also multiple perspectives about the historical emergence of transdisciplinarity, its relationship to scientific inquiry, and methods to achieve it.

The objectives of this book are twofold: (1) to offer insight into the spectrum of theoretical perspectives on collaborative research and collective learning and (2) to collate relevant cases of how collaborative research and collective learning have been successfully implemented in professional projects and integrated into academic programmes across cultural and disciplinary fields. It brings practitioners, theorists, researchers and educators together to talk to each other and to the reader. The authors are at different stages in their academic careers, they have different disciplinary stances, and they come from different educational institutions in Europe, China, Australia and the USA.

We believe the value of this book lies in bringing together a diverse group of academics, practitioners and researchers from eight countries to share how collaborative research and collective learning (Brown and Lambert 2013)—the essence of integrative approaches to research and inquiry—are deliberately designed and implemented across cultural divides, forms of theory and practice, and disciplinary fields. By collating international case studies across fields of sustainability, indigenous sovereignty, waste management and planning, community engagement, public health and educational design, this book presents a range of structural and conceptual designs for collaborative research and collective learning in both professional practice (i.e. consultancy, research) and development of academic curriculum programmes (i.e. undergraduate, graduate, postgraduate, and doctoral). The aim has been to draw on participants' empirical knowledge of designing, teaching, facilitating, and building capacity in programmes and projects through aligned processes such as 'design thinking', 'participatory action research' and 'systems thinking', all of which have the potential to facilitate collaborative research and collective learning. The final output is a rich collection of theoretical contributions and case studies that highlight how collaborative research might be implemented in practice.

This book provides a number of case studies of actual practice to give practitioners insights into how they can apply and adopt a process of collaborative research in their own fields of interest. These case studies take the reader through the experiences of researchers, educators, students and practitioners across a range of disciplinary perspectives. The book provides a range of cultural and theoretical viewpoints on collaborative research, including European, North American, Australian and indigenous perspectives. Finally, it highlights educational initiatives and curriculum development that facilitate collaborative research, spanning undergraduate, graduate postgraduate experiences—all of which are connected to practice-based projects.

This book has been structured in three sections: transdisciplinary theory/methods, pedagogy, and case studies. Although chapters are organized into one of these sections based on their primary focus, there is some overlap with other sections of the book and this is due to the tight connection between transdisciplinary thought and action. Throughout the book, authors provide their perspectives on the historical development, definitions and approaches of transdisciplinarity. Authors emphasize the major transdisciplinary challenges associated with thinking differently, teaching/learning differently and acting differently to understand and solve real-world problems.

The first section has a theoretical focus, led by **Julie Thompson Klein** (Chap. 2 in this book). Her chapter presents a conceptual vocabulary for learning in transdisciplinary collaborations, drawing first on insights about interdisciplinary education including integrative processes, *constructivism*, and *reflective equilibrium*. She describes the defining traits of transdisciplinary learning and the thematics of complexity and systems thinking. She also defines the core concepts of the co-construction of knowledge and mutual, generative, deep, double- and triple-loop learning. The vocabulary expands when factoring in *collective learning* in health and *transdisciplinary orientation* in team science. The conclusion reflects on the shift from *adaptive* and *generative learning* to *reflexivity, transformational learning, convergence, transactivity,* and *relational thinking*. Taken as a whole, the conceptual vocabulary in this chapter underscores the pivotal importance of communication in establishing platforms for, and a culture of, collaboration.

Linda Neuhauser (Chap. 3 in this book) traces the evolution of transdisciplinarity since the mid-1900s from two perspectives. One sees transdisciplinarity as a pragmatic approach to addressing the past failures of researchers and practitioners to identify complex problems and develop successful interventions. The other sees transdisciplinarity as a reflection of radical changes in thinking about the nature of reality and of scientific inquiry. These parallel practical and theoretical roots of transdisciplinarity provide a robust theoretical framework and a rich array of collaborative methods from natural, human and design sciences that help researchers, practitioners and other stakeholders to seek solutions to important problems in society.

Katie Ross and **Cynthia Mitchell** (Chap. 4 in this book) expand on existing characterizations of strong transdisciplinarity to develop the concept of *Transforming Transdisciplinarity*. Offering an extended, holistic critique, they highlight the importance of six integrated meaning-making systems, including: cosmologies, ontologies, epistemologies, axiologies, anthropologies, and social visions. They argue that in order to be transformative, collaborative transdisciplinary research should make space to reflect on the power and influence of these six meaning-making systems. The purpose of *Transforming Transdisciplinarity* is to offer a strong catalyst for collectively engaging in third order learning in collaborative research projects. **Jason Prior** (Chap. 5 in this book) and colleagues move the discussion into the realm of transdisciplinary thinking and suggest that transdisciplinarity is not only dependent on the consistency of disciplines, but is situated in their mutual malleability. Building upon these precepts, Prior argues that transdisciplinary education and research can contribute to our central task of becoming earth-centred and harmonious beings. This section concludes with a seminal paper by **Basarab Nicalescu** (Chap. 6 in this book) on the evolution of universities for sustainable development. He implies that academia must open itself to civil society and other places that produce new knowledge and, in the process, redefine the values governing its own existence.

Nicalesu's call for the reformation of universities segues into the second section of the book which brings together discussions on the educational virtues of transdisciplinarity and diverse collaborative educational practices. **Dena Fam** (Chap. 7 in this book) and her co-authors offer an illustrative example of the challenges faced by programmes aiming to institutionalize collaborative research and education. They provide insight into the process of collaboratively developing recommendations for how new programmes might support cultural change, successful planning, governance and the operationalization that crosses faculties and disciplines. **Kate Maguire** (Chap. 8 in this book) offers a different perspective from the UK, as she reflects on her institution's successful work-based learning programme, and how it has embraced transdisciplinarity as the epistemological perspective best suited for dealing with the messy problems encountered in the real world. **Alexander Crosby** and colleagues (Chap. 9 in this book) move the discussion from institutes and university-wide reform to the detail of developing a single course where the 'Transdisciplinary Living Lab Model (TDLL)' was offered as a way of positioning the university campus as a unique, and often overlooked site for transdisciplinary learning and collaboration. **Chris Riedy** (Chap. 10 in this book) and colleagues tackle the difficult, practical task of engagement in the university. Their chapter speaks to the reality of transdisciplinary research struggling to carve out a home within the rigid bureaucratic arrangements of universities where existing disciplinary structures can stifle collective learning and critical reflection across and beyond disciplines. Drawing on their experience from Australia, **Elizabeth Clarke and Craig Ashhurst** (Chap. 11 in this book) discuss a transdisciplinary methodology for research and teaching that is based on five principles that aim to address the key challenges associated with transdisciplinarity. They argue that the transdisciplinary process is iterative, and that it requires multiple learning cycles, particularly given that every partial solution to a wicked problem uncovers new problems. **Bin Bin Pearce** and colleagues (Chap. 12 in this book) reflect on curricula for sustainable development and how transdisciplinary skills and thinking might be better fostered. Drawing on their experience, they argue that being able to frame complex problems and empathize with diverse viewpoints are key skills for transdisciplinary learning and research. They offer a framework for how competence fields linked to different learning domains might better help students to develop cognitive, affective and psychomotor abilities. **Tanja Golja** and colleagues (Chap. 13 in this book)discuss the development of a transdisciplinary Master of Animation and Visualization. They examine the concept of collectivity in creative practice in the development of a curriculum grounded on critical and creative thinking, problem posing and solving, innovation and invention and complexity and collaboration which deliberately brings together academic researchers and industry partners to address complex creative problems.

The final section of the book offers cases to illuminate practice. In the first chapter in this section by **Jason De Santolo**, (Chap. 14 in this book) we are asked to reflect on our cultural epistemic positions for exploring knowledge outside of the hegemony of the Western tradition. In tracking key Garrwa principles and practices underlying sustainable autonomy, this music video case study reveals how ancient song traditions carry dynamic story world ecologies for protecting and sustaining life. The chapter explores the dynamics of working together and describes key elements in the process of design, implementation and making sense of research findings. **Linda Neuhauser** and colleagues (Chap. 15 in this book) describe how transdisciplinary theory and methods are being used in the Changzhou Worker Wellness Project to address the serious health and social problems of the over 250 million migrant workers who have moved to urban industrial factories in China. Although many prior "top down" government efforts were unsuccessful, project collaborators are obtaining positive outcomes by using highly participatory methods to engage factory workers, managers, government officials and researchers to identify underlying problems and design novel solutions.

Tania Leimbach and **Keith Armstrong** (Chap. 16 in this book) present a case study of collaborative research and public engagement in the arts, and highlight the potential for transdisciplinary learning within the gallery context. In particular, they explore the capacity for arts–science activities to shift public thinking in relation to globally relevant challenges such as sustainability, and posit that transdisciplinary arts–science practices can increase this capacity. **Brent Jacobs** and colleagues (Chap. 17 in this book) provide evidence of the critical importance of collective action in climate change adaptation projects. They put forward the Climate Adapted People Shelters (CAPS) project as a case in point. They call for community, government and scientific input and collaboration in developing smarter public transport infrastructure and urban design to improve the liveability of cities in an increasingly warmer world. In the final case study in this section **Valerie Brown** (Chap. 18 in this book) reflects on collective learning for whole-of-community change, and on the aim of collaborative action research in the 'Local Sustainability Project' over the past 10 years. The examples she offers cover the inception of the programme, the interest groups involved, their aims for the programme, the change strategies put in place, their successes and difficulties in practice, and the immediate and long-term outcomes.

Paul Gibbs (Chap. 19 in this book) concludes with the coda to the book. It offers a philosophical perspective on knowledge, and makes the claim that transdisciplinary and collective knowledges are enduring themes of the book, and that they have strong links to ancient history in Western thought. The coda brings into focus a central motivation of transdisciplinary work: to embrace complexity and have the courage to engage others across disciplines and sectors in our search for solutions to humanity's most critical problems.

This short introduction provides only the broadest of directions for the reader to explore the content of this book. The book is designed to be read in any way the reader chooses, either as a whole or as chapters of interest. We hope that it provides opportunities for collective and transdisciplinary thought throughout and inspires us all to use this powerful approach to better our world.

References

Bammer, G. (2003). *Interdisciplinarity: Integration and implementation sciences for researching complex real-world problems*. Canberra: Australian National University E-Press.

Brown, V. A., & Lambert, J. A. (2013). *Collective learning for transformational change: A guide to collaborative action*. Abingdon/Oxon/New York: Earthscan/Routledge.

Fam, D., Palmer, J., Reidy, C., & Mitchell, C. (Eds.). (2017). *Transdisciplinary research and practice for sustainability outcomes*. London: Routledge.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. London: Sage.

Gibbs, P. (2015). *Transdisciplinary professional learning and practice*. Dordrecht: Springer.

Jahn, T., Bergmann, M., & Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics, 79*, 1–10.

Jensen, P. S. (2003). Commentary: The next generation is overdue. *Journal of the American Academy of Adolescent Psychiatry, 42*(5), 527–530.

Kiefer, L., Frank, J., Di Ruggerio, E., Dobbins, M., Manuel, D., Gully, P. R., et al. (2005). Fostering evidence-based decision-making in Canada: Examining the need for a Canadian population and public health evidence centre and research network. *Canadian Journal of Public Health, 96*(3), I1–I19.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science, 7*, 25–43.

Lubchenco, J. (1998). Entering the century of the environment: A new social contract for science. *Science, 279*(5350), 491–497.

Neuhauser, L., & Pohl, C. (2014). Integrating transdisciplinary and translational concepts and methods into graduate education. In P. T. Gibbs (Ed.), *A transdisciplinary study of higher education and professional identity*. New York: Springer.

Neuhauser, L., Richardson, D., Mackenzie, S., & Minkler, M. (2007). Advancing transdisciplinary and translational research practice: Issues and models of doctoral education in public health. *Journal of Research Practice, 3*(2), M19.

Phelan, J. C., Link, B. G., & Tehranifar, P. (2010). Social conditions as fundemental cof health inequalities; Theory, evidence and policy implications, *Journal of Health and Social behavior, 51* (1supplement) S28–S40.

Robinson, J. (2008). Being undisciplined: Transgressions and intersections in academia and beyond. *Futures, 40*, 70–86.

Stokols, D. (2006). Toward a science of transdisicplinary action research. *American Journal of Community Psychology, 38*, 63–77.

Westberg, L., & Polk, M. (2016). The role of learning in transdisciplinary research: Moving from a normative concept to an analytical tool through a practice-based approach. *Sustainability Science, 11*, 385–397.

Wickson, F., Carew, A. L., & Russell, A. W. (2006). Transdisciplinary research: Characteristics, quandaries and quality. *Futures, 38*, 1046–1059.

Chapter 2
Learning in Transdisciplinary Collaborations: A Conceptual Vocabulary

Julie Thompson Klein

2.1 Introduction

Collaboration is an increasingly prominent mode of research across academic, industrial, military, and community settings. Widening interest in this topic is apparent in the international scope of references for this chapter, which presents a conceptual vocabulary of learning in transdisciplinary collaboration in teams. Not all teams are interdisciplinary or transdisciplinary. They also appear within disciplinary and professional domains. Even when limiting the focus to interdisciplinary and transdisciplinary teams, variations also appear in their types and goals, their sizes and structures, their degrees of integration, and their mixes of disciplines, fields, and professions. In addition, levels of analysis differ across projects and programmes, organizations, and sectors of society. Table 2.1 is a glossary of the key concepts employed in the study, including the core terms *interdisciplinarity* (*ID*) and *transdisciplinarity* (*TD*). The prefix "inter" typically connotes the integration of existing methods, tools, concepts, and theories from two or more disciplines, and the linking and blending of these elements in order to advance fundamental understanding, or to address a complex problem or question. The prefix "trans" connotes transcending disciplines through an overarching set of axioms associated historically with unity of knowledge and later synthetic paradigms. More recently, the term *transdisciplinarity* has also become associated with problem-oriented research that generates new conceptual and methodological frameworks and involves stakeholders in society in the research process. (For a fuller account of definitions, see Klein 2017b).

J. T. Klein (✉)
Department of English, Wayne State University, Detroit, MI, USA
e-mail: ad5820@wayne.edu

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_2

Table 2.1 Glossary of key terms for learning in transdisciplinary collaborations

Adaptive* and *generative team learning	Adaptive learning entails acquiring new knowledge or skills and adjusting to an environment to improve team performance. Generative learning entails developing new knowledge and variables with the potential for changes in norms, values, and goals.
Collaboration and collaborative learning	Collaboration entails proactive interaction among individuals from different disciplines and fields in a process that has the potential to create collaboration knowledge. Collaborative learning fosters a shared conception of a problem or question through communication and mutual engagement.
Collective communication competence	Collective communication competence is social in nature, and builds common ground when members of a team work together to sort through different perspectives and generate new shared understandings. It recognizes interrelationships among communicators, goals, participants' abilities to integrate knowledge and expertise, and a range of interpersonal and organizational contexts.
Constructivism and co-construction of knowledge	Constructivism holds that knowledge is socially created. In education, creation of knowledge is linked with discovery and interaction, and it aligns inquiry with advancing understanding. In transdisciplinary research, it is also associated with co-creation of knowledge.
Integrative learning	Integrative learning goes beyond "multidisciplinary" juxtaposition of separate disciplinary approaches to construct a new holistic outcome. Definitions have shifted historically from content to process integration and from synthesis of accepted postulates to building new conceptual modes.
Interdisciplinarity (ID)	ID is typically defined as integration of existing methods, tools, concepts, theories, and epistemologies from two or more disciplines, and their linking and blending in order to address a complex problem, question, theme, or topic in education and in research.
Mutual learning	Mutual learning fosters collaboration when members of teams learn about each other's approaches. It is context dependent, and it evolves through social interaction and respect for others' views. It is also aligned with both personal change and the capacity of a group to work together toward a common goal.
Reflexivity* and *reflective equilibrium	Reflexivity is both introspective and collective. It challenges taken-for-granted assumptions, fostering epistemological flexibility. In the learning process, new insights and prior knowledge are weighed against each other to produce an equilibrium that is purposeful, pluralistic, and provisional.
Relational thinking	Relational thinking represents a conceptual leap beyond pre-made methods, and creating new ways of thinking and acting to deal with complexity. A form of situated learning, relationality opens the possibility of informed critical reflection and even creation of a knowledge management system at the level of an organization, not just teams.

(continued)

Table 2.1 (continued)

Socio-cognitive platforms for interdisciplinary collaboration* and *cooperation and communication culture	Platforms foster social and cognitive integration by providing a foundation for group membership and collective norms. A project-specific communication culture attends to interfaces where the work of one participant is necessary for the work of another and participants can collaborate effectively.
Transactivity	Transactivity connotes shared knowledge in the form of mental models and awareness of "who knows what" in the memory system of a team and a research programme. Individuals develop a group-level system for encoding, storing, and retrieving information that unfolds in two phases: specialization and coordination achieved through communication.
Transdisciplinarity (TD) and transdisciplinary orientation	Multiple forms of research and education are associated with synthetic frameworks, including general systems theory, post/structuralism, feminist theory, and sustainability. The term also appears in conjunction with critiques of knowledge and education, real-world problem solving involving participation of stakeholders in research, and new conceptual and methodological frameworks.
Transformational learning* and *deep learning	Transformational learning is learning that transcends habitual thought patterns and behaviour through deep learning that changes frames of reference, assumptions, and habits of mind. Shared knowledge and mental models foster convergence, constructed through dialogue and artifacts of learning capable of bringing about lasting change.
Transdisciplinary orientation	A transdisciplinary orientation is a synergistic combination of values, attitudes, beliefs, skills, knowledge, and behaviours that predisposes individuals to collaboration. They promote team participation marked by willingness to learn about unfamiliar theories and methods and to adjust individual disciplinary schema to fit the demands of teamwork.

2.2 *Integrative Learning* in Interdisciplinary Education[1]

The definition of *integrative learning* in interdisciplinary education is a logical place to begin because more has been written on the topic over a longer period of time in literature on interdisciplinarity than in literature on transdisciplinarity. Klein (2005) and Boix-Mansilla and Lenoir (2010) date the term "integration" in education to books in the mid- and late-nineteenth century on principles of psychology by Herbert Spencer and William James, as well as Alexis Bertrand's theory of integrated instruction. During the 1800s, the concept of integration was also linked with the role schools play in promoting social unity and the Herbartian movement's doctrine of correlation, which supplemented the doctrine of concentration on individual subjects by recognizing interrelationships. The proper locus of integration, though, was a matter of debate. Some considered a canon of texts to be the basis for unity of knowledge, while others focused on the process of knowing. Two shifts in definition foreshadowed the current focus on process in both interdisciplinarity and transdisciplinarity. Participants in a 1935 meeting sponsored by the US-based National

Education Association, and a 1937 book on the topic of integration concluded complete unity is impossible. They proposed, instead, thinking of "unifying" rather than "unified" approaches. Subsequently, members of a 1948 workshop sponsored by the Foundation for Integrative Education distinguished between *content integration*, which bridges subjects of study, and *process integration,* which occurs in the interplay of an individual and an environment. They also differentiated *integration* as a synthesis of accepted postulates from *integrative* building of new conceptual modes capable of producing a holistic experience (summarized in Ciccorio 1970).[1]

Boix-Mansilla and Lenoir (2010) suggest John Dewey was the first to advocate interdisciplinarity in conjunction with integration, in a holistic process that entails learning-by-doing and bridges experience within and outside school. Dewey treated learning as a form of social inquiry that increases learners' capacity to think critically and solve problems collectively. *Integrative learning* has also been associated theoretically with Herbert Spencer's synthetic philosophy of knowledge, organismic psychology, Gestalt psychology, and the Progressivists' democratic model of education. Based on both a literature review and work with teachers, Boix-Mansilla (2017) concludes pragmatic *constructionism* is the epistemological foundation for interdisciplinary learning, and aligns inquiry with advancing understanding rather than acquiring or certifying "true" knowledge claims. Prior knowledge and new insights, she adds, are weighed against one another to produce *reflective equilibrium*. When students encounter differences in disciplinary perspectives, they experience what Jean Piaget called "cognitive disequilibrium." The most effective resolution, Piaget suggests, is to invent a higher-order construction which moves beyond a one-dimensional view, and to adopt a multidisciplinary mix by building "metaperspectives" (See also Hursh et al. (1983) for a model of interdisciplinary education based on learning theories of Dewey, Piaget, and William Perry).

The theoretical tenets of process-based integrative learning and constructivism are also prominent in literature on transdisciplinarity. Learning has not been a primary focus of that literature in the past, but it is gaining recognition. Paul Gibbs' 2015 collection of essays, *Transdisciplinary professional learning and practice*, spans a range of topics including curricular structures, health care settings, links with applied sciences, cross-sector partnerships, student skills and attitudes, team coaching, translation, and the concept of collective mind. And, a subsequent 2017 collection edited by Gibbs, *Transdisciplinary higher education*, spans topics ranging from philosophical warrants for transdisciplinarity to pedagogies and curricula that foster connectivity and common ground. The authors further identify a number of defining traits of transdisciplinary learning, including flexibility, adaptability, and reflexivity as well as participation, dialogue, and collaboration. The picture that emerges across chapters in this collection highlight the social nature of learning and the bridging of cognition, skills, and dispositions. In a detailed account, Sue McGregor (2017) links transdisciplinary learning explicitly with drawing together

[1] This section on *Integrative learning* in Interdisciplinary Education draws on Klein (2005).

disciplinary and stakeholder forms of knowledge, and with co-creating transdisciplinary knowledge in a process that is iterative and transformative, while also addressing social problems and invoking unity of knowledge. She also links the learning cycle with common learning and change; habits of mind including patterning, modeling, and synthesizing; and the concepts of double-loop learning and reflection-in-action.

The present chapter examines related question more deeply by presenting a conceptual vocabulary of transdisciplinary learning with an emphasis on collaboration.

2.3 Learning in Transdisciplinary Collaborations

In a review of literature on team learning in organizations, Decuyper et al. (2010) found 30 different definitions and discussions. Studies of collaboration place different emphases on processes, structures, and outcomes. Bedwell et al. (2012) contend, however, that structures and outcomes do not constitute collaboration. Rather it is a process for achieving outcomes. Vanasupa et al. (2014) also report current discourse about transdisciplinary research often uses metaphors that accentuate production. Images of building, designing, scaling up, prototyping, and generating products of knowledge evoke values of efficiency, productivity, quality control, uniformity, cost/benefit ratios, and economies of scale. Instead, Vanasupa, et al. propose the metaphor of complex systems and, comparably, Decuyper et al. (2010) anchor a theoretical framework for team learning in the paradigm of complex systems. Teams are composed of interdependent members in open systems with permeable boundaries and interconnecting subsystems involving both team members and their environment.

The link between interconnecting and learning is associated with other concepts as well, including *collaborative learning* in the work of Kenneth Bruffee and others. Recalling the rise of collaborative learning research in the 1970s, Michael J. Baker (2015) notes multiple reasons for its emergence, including: a practical need for students to share scarce resources such as computers; reactions to approaches centred on individual learners; changes in authority structures that allowed students' voices to be heard in classrooms; and, a prominent factor in current discourses of interdisciplinarity and transdisciplinarity, social changes that require individuals to learn to work with others in an increasingly globalized world. The terms "cooperative learning" and "collaborative learning" are sometimes used synonymously, but Baker highlights a widely recognized distinction. Cooperative learning typically entails divisions of labor, with each participant being responsible for part of a shared goal. In contrast, collaboration is a coordinated, synchronous activity resulting from continued attempts to construct and maintain a shared conception of a particular problem. Cooperation helps facilitate collaboration. However, collaboration assumes a high degree of joint attention, communication, interaction, mutual engagement, and co-elaboration of knowledge.

Several additional concepts expand the vocabulary used to describe learning in transdisciplinary collaborations. Mitchell et al. (2015, 2017) highlight *mutual* and *transformative learning*, coupling them as one of three "outcomes spaces" of transdisciplinary research, along with the situation or field of inquiry and relevant stocks and flows of knowledge. *Mutual learning* evolves through social interaction and is context-dependent. It is less about a particular theory, they add, than it is about purpose and it is aligned with personal change, *deep learning,* and *triple-loop learning*. Argyris and Schön (1996) associate single-loop learning with assessing performance against established rules or standards in order to detect and correct errors. In *double-loop learning,* underlying assumptions, norms, objectives, policies, goals, and programmes are questioned in a form of *generative learning* that adapts to change and complexity through collaborative action, dialogue, and reflection. Argyris and Schön do not mention *triple-loop learning* explicitly. However, the concept connotes a higher or deeper level in the literature on organizational learning, a level which occurs when processes or methodologies generate new and even transformative principles or paradigms and reflection on learning process. (See Tosey et al. 2011 on theories of learning levels.)

W. D. Bellotti's (2017) account of a transdisciplinary agricultural project in the rural East India Plateau illustrates the power of *transformative learning*. The project aimed to improve livelihoods for indigenous farmers by intensifying and diversifying the cropping system. It unfolded in three phases: (1) building a team and collaborative problem framing, (2) creating actionable research that included learning as a planned outcome, and (3) integrating and applying new knowledge including intensive learning experiences. The first phase was a three-day workshop involving development professionals and scientists. Their initial assumption was that farmers would become familiar with new practices, but over the course of the project farmers also gained confidence in initiating experiments. Bellotti aligned steps of the research process with the three outcome spaces defined by Mitchell et al. (2015, 2017): spaces focused on improving a situation, generating knowledge, and learning. Farmers' participation in research proved effective for both individual and collective learning in self-help groups. Moreover, farmers provided training in new agricultural practices to neighboring villages and even government officials. Experiential learning also changed participants' perceptions of self and their ways of using land and water more productively for multiple crops. And, women villagers came to see themselves as farmers instead of laborers while also becoming teachers of others. Ultimately, a year-round crop planning tool was developed to facilitate continued learning about resources.

2.4 *Collective Learning* in the Field of Health

Bellotti's case study is one of many examples documenting the growing alignment of transdisciplinarity and sustainability (Klein 2017a, b). The field of health is also increasingly focused on interdisciplinary and transdisciplinary research and education. Gehlert and Browne (2013) found that degree programmes in public health tend to bring students from different backgrounds together for training, or they feature instructors from different areas of expertise in the same curriculum. In successful programmes trainees become effective team members by learning about group process skills, communication, negotiation, and conflict resolution through shared exercises and projects as well as problem-based and experiential learning. Angus McMurtry (2013) adds that educational theorists are using the terms "collective" and "sociomaterial" to describe theories of learning that move beyond a traditional focus on individuals in educational literature. He does not mention "transdisciplinarity," but does emphasize the common imperative of solving complex problems in "interdisciplinary" and "interprofessional" work. The latter term connotes teamwork by physicians, nurses, therapists, social workers, other care professionals, and in some cases stakeholders including patients. McMurtry identifies parallel features of integration in the literature on ID and on interprofessionalism he links to four theoretical discourses of collective or sociomaterial learning.

The first discourse–Communities of Practice–is based on Lave and Wenger's (1991) theory that groups of people who share a concern or passion learn to work better through regular interactions. This kind of *collective learning*, McMurty emphasizes, is conceived in social terms. As individuals participate in a community of practice, akin to moving from apprenticeship to mastery, knowing and identity become located in relationships. This approach to social learning, he adds, links diverse perspectives with participation in a community in which constructing common ground and negotiating conflict are needed if synthesis is to occur. The need to negotiate conflict is also prominent in literatures on interdisciplinarity and on transdisciplinarity. Decuyper et al. (2010) identify conflict as one of the major barriers to team learning in transdisciplinary contexts, and they link the notion of "constructive conflict" with a dialogical space in which discordant and constructive learning processes may co-exist. Teams will only learn effectively, they emphasize, when their members keep finding equilibrium in the tensions between "conflict" and "harmony."

The second theoretical discourse—Cultural-Historical Activity (CHAT)—also treats learning in terms of social processes and collectives, inspired by the work of Vygotsky, Ilyenkov, and other thinkers influenced by Marx. Theorists focus on activity systems rather than individuals as primary units for analysis, encompassing not only people but also their tools, rules, divisions of labor, and objects of common focus. Individuals are embedded within a social matrix and material artifacts that transmit knowledge, while also mediating ways that individuals interact with each other and their environments. Here too, tensions and contradictions play a role in learning, underscoring the need for negotiating conflicts. As interdisciplinary and transdisciplinary teams build common ground by sorting through different perspectives and generating new shared understandings, they also combine human and material resources. Calling attention to the role of tools and technologies in team learning within organizations, Decuyper et al. (2010) liken shared knowledge, procedures, ideas, plans, and habits to the software and hardware of a team. "Software" connotes non-material repositories, such as individual memory, shared mental models, and a transactive memory system. “Hardware” connotes material such as computer databases, bulletin boards, expert systems, artifacts, and paper.

As indicated earlier, the third discourse—Complexity Science—is a recognized framework in literatures on interdisciplinarity and on transdisciplinarity. Many communication scholars, Jessica Leigh Thompson (2009) reports, use systems theory to explain the complexity of small group interactions in changing environments. The US-based National Research Council’s (NRC’s) report on *Enhancing the effectiveness of team science* also views communication and coordination through the lens of complexity science. The aggregate behaviour of a system emerges from intersections of its parts in a dynamic network of nonlinear interactions that produce self-organization and emergence. Researchers in organization science regard effectiveness as emergent because it originates in thinking and behaviour of individuals and is amplified by interactions (National Research Council 2015). Like Complexity Science, the fourth discourse—Actor Network Theory—also locates learning and knowing beyond individual cognition. They emerge in relations and interactions within networks. Based on studies of interdisciplinary teams, Thompson (2009) places *collective communication competence* at the heart of interdisciplinary collaboration, recognizing interrelationships between communicators, goals, and participants’ abilities to integrate knowledge and expertise in a range of interpersonal, relational, organizational, and pedagogical contexts. In another study of research programmes and networks, Boix-Mansilla et al. (2015) introduced the concept of *socio-cognitive platforms for interdisciplinary collaboration*. And, Schmithals and Berhenhage emphasized the importance of establishing a project-specific *cooperation and communication culture* in transdisciplinary research; doing so establishes interfaces where the work of one participant is necessary for the work of another (cited in Bergmann et al. 2011; Bergmann 2012).

2.5 *Transdisciplinary Orientation* in Team Science

More attention has been paid to individuals than groups or teams in literatures on learning in general and on interdisciplinary education. Yet, Decuyper et al. (2010) contend the relationship is dialectical. Likewise, Volet et al. (2009) caution against reducing analysis to either individual or social levels. Individuals, though, still need to develop a personal capacity for collaboration. In defining the characteristics of transdisciplinary individuals, Tanya Augsburg (2014) affirms Bruce et al.’s (2004) list of ideal qualities: curiosity about, and a willingness to learn from, other disciplines; flexibility and adaptability; an open and creative mind, good communication and listening skills; and the capacity to absorb information. Augsburg adds reflection on processes of knowledge integration and a willingness to take risks.

Additional studies shed light on what individuals need in order to collaborate successfully. Research on learning in psychology and education reveals three categories of competencies for successful outcomes, cited in an NRC report on team science:

- team knowledge (e.g., task understanding, shared mental models, role knowledge)
- team skills (e.g., communication, assertiveness, situation assessment)
- team attitudes (e.g., team orientation, trust, cohesion). (National Research Council 2015, p. 98)

Misra et al. (2015) link competencies with the concept of *transdisciplinary orientation.* A synergistic combination of values, attitudes, beliefs, skills, knowledge, and behaviours predisposes individuals to collaboration. Values, in particular, are guiding principles that incline members of teams to participate and work with others, and to learn about unfamiliar theories and methods. The attitudes involved include a willingness to invest time in learning and a willingness to adjust individual disciplinary conceptual schema to fit the demands of teamwork. The behaviours, in turn, include learning activities such as participating in team projects. Fam's (2017) matrix of methods and practices for building transdisciplinary competencies also affirms the combination that Misra et al. (2015) identified but adds openness to learning from others and career-long learning.

Individuals gain related competencies in multiple settings. The NRC report on team science distinguished "education" within curricular settings from "training" or "professional development" that typically occurs outside the classroom and may range from an hour-long presentation on a particular topic to an intervention such as a multi-day retreat aimed at improving a team's performance. The focus of training varies as well. It may concentrate on specific tasks or the process of teamwork or both, and it may concentrate on immediate contexts or transportable competencies. Bedwell et al. (2012) identify two broad approaches to training. The first is generic: fostering of transportable skills across teams, goals, and contexts. The second is bringing collaborators together, and sharpening their focus on a designated problem. The NRC report further cites cross-training to learn skills and roles of other team members. This approach improves interactions and encourages the development of shared mental models. Learning also occurs in the process of teamwork, though turnover in membership is associated with disruption. Van der Vegt et al. (2010) suggest that turnover could promote team learning behaviour by encouraging reflection on functioning. Teams develop routine patterns that reduce the felt need for communication and reflection. Turnover may also spur intra-team learning by introducing new members who bring new ideas and approaches from previous settings. Small amounts of turnover, they conclude, may then promote learning behaviour while fostering the "mindful reflection" associated with higher levels of thinking and acting.

2.6 Conclusion: From *Adaptive* and *Generative Learning* to *Transformational Learning, Convergence, Reflexivity, Transactivity,* and *Relational Thinking*

Decuyper et al. (2010) identify three metaphors in literature on team learning: acquisition (sharing, storage, and retrieval), participation (boundary crossing, team activity, and team reflexivity), and creation (co-construction and constructive conflict). They consider the three metaphors to be complementary and of equal importance, though emphasis shifts from gaining "knowledge" in the "acquisition" metaphor to "knowing" in participation and creation metaphors. The third metaphor (creation) also marks a shift from team learning as a collaborative adaptation to expansion and innovation. Decuyper, Dochy, and Van den Bossche (2010) resist designating one perspective as "right" or the "best," but discussions often highlight movement towards higher-level thinking and the possibility of transformation. *Adaptive team learning,* they explain, involves acquiring new knowledge or skills and adjusting to a particular environment. *Generative team learning* entails developing new knowledge and variables with potential for changes in norms, values, and goals. *Transformational team learning*, in contrast, involves applying "revolutionary ideas" and creating "radically new variables."

Jeong and Chi (2011) also link *collaborative learning* with the concept of *convergence* resulting from increases in shared knowledge and mental models. Social interaction facilitates mutual understanding and increased similarity between cognitive representations. Weinberger et al. (2007) conceptualize knowledge convergence in three stages. The first—sharing—occurs when learners possess the same concepts. The second—equivalence—connotes a similar degree of knowledge about a subject prior to collaboration. The third stage—*convergenc*e—occurs during collaborative learning. It is a group-level phenomenon, though individuals may still benefit in different ways from learning together. *Collaborative learning* is further associated with *reflexivity*. Jahn et al. (2012) contend reflexivity is central to the practice of transdisciplinary research. Reflexivity is transgressive. It challenges dominant assumptions and power structures, and it is transcendent, as it involves epistemological flexibility and synergies between disciplinary and cultural knowledge. Writing in the context of nursing and social work, Clark et al. (2015) further link reflexivity with the potential for equitable relations, an increased capacity for collaboration, and transdisciplinary conceptual and theoretical frameworks for understanding the roles of environments and social contexts in health. Reflexivity, they add, is both introspective and collective. It involves critiquing and problematizing taken-for-granted ideologies while fostering an ethics and a social politics of accountability.

Learning in transdisciplinary collaboration is linked with concepts of *transactivity* and *transformational learning* as well. Decuyper et al. (2010) associate *transactivity* with the degree to which learners acquire shared knowledge in the form of mental models and a transactive memory system in the form of "who knows what." Individuals develop a group-level system for encoding, storing, and retrieving information that unfolds in two phases: specialization in the form of individuals' expertise, and coordination achieved through communication. Conflict-oriented consensus building, they add, is one of the highest transactive social modes. It is achieved through negotiation and dialogue. *Transformational learning* is the most far-reaching form. Vanasupa et al. (2014) highlight Jack Mezirow's (2003) definition of "[l]earning that transforms problematic frames of reference—sets of fixed assumptions and expectations (habits of mind, meaning perspectives, mindsets)—to make them more inclusive, discriminating, open, reflective, and emotionally able to change." Some contend that *mutual* and *transformative learning* have an increased likelihood of sustainability. Rodrigo Lozano (2014) cautions, however, that transformational change in mental models and behaviour requires long-term learning. *Transformational learning* is also emancipatory. Its purpose is enlightenment, the transcendence of habitual thought and behaviour through *deep learning*.

Finally, transformative learning fosters *relational thinking*. Tony Fry (2011) argues that transdisciplinarity in architecture and urban planning is a form of "relational thinking" that not only dissolves disciplinary differences but constitutes a conceptual leap beyond pre-made methods. It is a form of "redirective practice" that creates new ways of dealing with complexity. "Problems are never received," Fry asserts, "but always interrogated and redefined." *Relational thinking* could even result in a new knowledge management system at the level of the organization, not just individual teams. The insight this concept provides extends beyond architecture and urban planning, across all contexts of transdisciplinary research. It accentuates interrelationships in collective efforts to integrate knowledge and expertise in a process-based co-construction of knowledge within dialogical spaces and cultures. According to Misra et al. (2015) these relationships are fostered by the transdisciplinary orientations of individuals, and by their agreement on a shared goal through discussing differences and building common ground.

References

Argyris, C., & Schön, D. A. (1996). *Organizational learning II: Theory, method and practice*. Boston: Addison-Wesley/Pearson.

Augsburg, T. (2014). Becoming transdisciplinary: The emergence of the transdisciplinary individual. *World Futures: The Journal of New Paradigm Research, 70*(3–4), 233–247.

Baker, M. J. (2015). Collaboration in collaborative learning. *Interaction Studies, 16*(3), 451–473.

Bedwell, W., Wildman, J., DiazGranados, D., Salazar, M., et al. (2012). Collaboration at work: An integrative multilevel conceptualization. *Human Resource Management Review, 22*, 128–145.

Bellotti, B. (2017). Transdisciplinarity as an emergent property in an agricultural research-for-development project on the East India Plateau. In D. Fam, D. Riedy, & E. C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability* (pp. 221–235). London: Routledge.

Bergmann, M., Jahn, T., Knobloch, T., Krohn, W., Pohl, C., & Schramm, E. (2011). *Methoden transdisziplinärer forschung: Ein uberblick mit anwendungsbeispielen*. Frankfurt/Main: Campus Verlag; English translation *Transdisciplinary research methods* (2012). Frankfurt/Main/Chicago: Campus Verlag/University of Chicago Press.

Boix-Mansilla, V. (2017). Interdisciplinary learning: A cognitive-epistemological foundation. In R. Frodeman, J. T. Klein, & R. Pacheco (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 261–275). Oxford: Oxford University Press.

Boix-Mansilla, V., & Lenoir, Y. (2010). Interdisciplinarity in U.S. schools: Past, present, and future. *Issues in Integrative Studies, 28*, 1–28.

Boix-Mansilla, V., Lamont, M., & Sato, K. (2015). Shared cognitive-emotional interactional platforms: Markers and conditions for successful interdisciplinary collaborations. *Science, Technology, and Human Values, 41*(4), 571–612.

Bruce, A., Lyall, C., Tait, J., & Williams, R. (2004). Interdisciplinary integration in Europe: The case of the Fifth Framework Programme. *Futures, 36*(4), 457–470.

Ciccorio, R. A. (1970). Integration in the curriculum: An historical and semantic inquiry. *Main Currents, 27*, 60–62.

Clark, N., Handlovsky, I., & Sinclair, D. (2015). Using reflexivity to achieve transdisciplinarity in nursing and social work. In N. Greaves & B. E. Poole (Eds.), *Transforming additions: Gender, trauma, transdisciplinarity* (pp. 120–136). London: Routledge.

Decuyper, S., Dochy, F., & Van den Bosschec, P. (2010). Grasping the dynamic complexity of team learning: An integrative model for effective team learning in organizations. *Educational Research Review, 5*, 111–133.

Fam, D. (2017). Unpublished MS. *Methods and practices to build and strengthen transdisciplinary competencies*.

Fry, T. (2011). Getting over architecture: Thinking, surmounting, and redirecting. In I. Doucet & N. Janssens (Eds.), *Transdisciplinary knowledge production in architecture and urbanism* (pp. 24–27). Cham: Springer.

Gehlert, S., & Browne, T. (2013). Transdisciplinary training and education. In D. Haire-Joshu & T. McBridge (Eds.), *Transdisciplinary public health: Research, education, and practice* (pp. 31–51). San Francisco: Wiley.

Gibbs, P. (2015). *Transdisciplinary professional learning and practice*. Cham: Springer.

Gibbs, P. (2017). *Transdisciplinary higher education: A theoretical basis revealed in practice*. Cham: Springer.

Hursh, B., Haas, P., & Moore, M. (1983). An interdisciplinary model to implement general education. *Journal of Higher Education, 54*(1), 42–59.

Jahn, R., Bergmann, M., & Keil, F. (2012). Transdisciplinarity, between mainstreaming and marginalization. *Ecological Economics, 79*, 1–10.

Jeong, H., & Chi, M. (2011). Knowledge convergence and collaborative learning. *Instructional Service, 35*, 287–315.

Klein, J. T. (2005). Integrative learning and interdisciplinary studies. *Peer Review, 7*(4), 8–10.

Klein, J. T. (2017a). Transdisciplinarity and sustainability: Patterns of definition. In D. Fam, C. Riedy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainable outcomes* (pp. 7–21). London: Routledge.

Klein, J. T. (2017b). Typologies of interdisciplinarity: The boundary work of definition. In R. Frodeman, J. T. Klein, & R. Pachecho (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 21–34). Oxford: Oxford University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: University of Cambridge Press.

Lozano, R. (2014). Creativity and organizational learning as means to foster sustainability. *Sustainable Development, 22*, 205–216.

McGregor, S. L. T. (2017). Transdisciplinary pedagogy in higher education: Transdisciplinary learning, learning cycles, and habits of mind. In P. Gibbs (Ed.), *Transdisciplinary higher education: A theoretical basis revealed in practice* (pp. 3–16). Cham: Springer.

McMurtry, A. (2013). Reframing interdisciplinary and interprofessional collaboration through the lens of collective and sociomaterial theories of learning. *Issues in Interdisciplinary Studies, 31*, 75–98.

Mezirow, J. (2003). Transformative learning as discourse. *Journal of Transformation Education, 1*, 58–63.

Misra, S., Stokols, D., & Cheng, L. (2015). The transdisciplinary orientation scale: Factor structure and relation to the integrative quality and scope of scientific publications. *Journal of Translational Medicine and Epidemiology, 3*(2), 1042+.

Mitchell, C., Cordell, D., & Fam, D. (2015). Beginning at the end: The outcome spaces framework to guide purposive transdisciplinary research. *Futures, 65*, 6–96.

Mitchell, C., Cordell, D., & Fam, D. (2017). Beginning at the end: The outcome spaces framework to guide purposive transdisciplinary research. In D. Fam, C. Riedy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability* (pp. 25–38). London: Routledge.

National Research Council, Hilton, M., & Cooke, N. (2015). *Enhancing the effecctiveness of team science*. Washington, DC: National Academies Press.

Thompson, J. L. (2009). Building collective communication competence in interdisciplinary research teams. *Journal of Applied Communication Research, 37*(3), 278–297.

Tosey, P., Visser, M., & Saunders, N. K. (2011). The origins and conceptualizations of "triple-loop" learning: A critical review. *Management Learning, 43*(3), 289–305.

Van der Vegt, G. S., Bunderson, S., & Kuipers, B. (2010). Why turnover matters in self-managing work teams: Learning, social integration, and task flexibility. *Journal of Management, 36*(5), 1168–1191.

Vanasupa, L., Schlemer, B. R., Brogno, C., Hendrix, G., & MacDougall, N. (2014). Laying the foundation for transdisciplinary faculty collaborations: Actions for a sustainable future. *Sustainability, 6*, 2893–2928.

Volet, S., Vaurus, M., & Salonen, P. (2009). Self- and social regulation in learning contexts: An integrative perspective. *Educational Psychologist, 44*(4), 215–226.

Weinberger, A., Stegmann, K., & Fischer, F. (2007). Knowledge convergence in collaborative learning: Concepts and assessment. *Learning and Instruction, 17*, 416–426.

Chapter 3
Practical and Scientific Foundations of Transdisciplinary Research and Action

Linda Neuhauser

3.1 Introduction

One of the greatest challenges in society is to solve seemingly intractable problems like poverty, disease, conflict and environmental degradation. We concur with the other authors of this book, and many other scholars, in believing that the answer lies in developing and applying knowledge across diverse disciplines and sectors, or transdisciplinarity. Transdisciplinary work is a major challenge, given that higher education—a training ground for influential leaders—is moving toward increasing disciplinary specialization and, therefore, fragmentation of thought and action. Fortunately, as described in this book, we can draw on rich theoretical and empirical contributions over the millennia to guide and support our transdisciplinary efforts. Together, we can learn a lot from the issues and successes encountered in real-world transdisciplinary efforts.

There are three objectives for this chapter: (1) to briefly describe the value of transdisciplinary guidance to address complex problems; (2) to provide a rationale for drawing on the design sciences as an important scientific foundation to advance transdisciplinary problem solving; and (3) to emphasize the power of deep participatory strategies for transdisciplinary work. The transdisciplinary principles described in this chapter are illustrated in another chapter in this book (Chap. 15) which describes a case study of the complex problem of supporting the health and wellness of over 250 million Chinese migrant workers.

L. Neuhauser (✉)
School of Public Health, University of California, Berkeley, CA, USA
e-mail: lindan@berkeley.edu

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_3

3.1.1 The Emergence of Transdisciplinarity to Address Complex Problems

The transdisciplinary movement was directly catalyzed by the practical challenges of addressing complex problems in society. Researchers, practitioners and policy-makers have long critiqued the disappointing results of efforts to conduct and implement research that benefits society. Since the mid-twentieth century there has been a strong focus on the challenge of addressing highly complex and seemingly intractable problems. Stakeholders have identified major deficiencies in traditional research approaches. These deficiencies are related to: (1) research integration; (2) research translation and implementation; and (3) participatory processes.

3.1.2 Research Integration for Complex Problems

In an ideal world, researchers and stakeholders who implement research would have access to knowledge from many disciplines. However, in reality, most researchers work primarily in a limited number of disciplines and in institutions in which knowledge is becoming increasingly specialized into sub-disciplines (Bammer 2013; Lubchenco 1998). There is often great frustration with the poor results of interventions intended to improve people's lives. Typically, research studies do not go deeply or broadly enough into the fundamental determinants of problems (Phelan et al. 2010). As a result, many interventions have a minimal impact.

For example, regarding the aforementioned case study (Chap. 15 in this book) of Chinese migrant workers (who experience serious health problems), the traditional government approach was to view worker health as primarily a medical issue, and therefore to assume that the solution was to provide health services. However, this narrow approach ignored many other underlying key determinants of worker health such as social connections, education, access to information, diet, and exercise. As described in the case study, collaborators learned that a more effective approach required "deconstructing" the many socio-cultural and environmental factors related to workers' health and wellness in order to create successful interventions.

During the past 50 years, there has been an increasing focus on examining the underlying determinants of a problem, including for the groups most at risk (Smedley and Syme 2000; Whitehead 1991). The World Health Organization's "Solid Facts" (Wilkinson and Marmot 2003) provides important guidance about key determinants of health that should be considered in research studies and intervention design. Examining deep and broad determinants of health over time (Halfon and Hochstein 2002), and within diverse population groups, requires sophisticated strategies to integrate research across many disciplinary areas.

Models of research integration involving diverse disciplines began to increase in number in the 1990s (Neuhauser et al. 2007). These models were often called "interdisciplinary" and focused on theory, and on methods of bringing together researchers and (sometimes) professionals of diverse disciplinary backgrounds to work effectively on a common problem. Many of the early research integration models tended to be linear, and viewed research as a product to be passively transferred from researchers to implementers in real-world settings (Best et al. 2006). For example, the US National Institutes of Health (the major US government funder of health research) initially defined a two-phase "roadmap" model in which basic research would take place in a laboratory, after which practitioners would translate it into interventions (Woolf 2008). In a critique of the model, Rubio et al. (2010) commented that it overlooked the importance of involving multiple knowledge sets, methods and stakeholders. They argued that these things needed to be considered for research to benefit society. Research integration models were valuable in that they identified specific evidence-based factors to motivate and support researchers of diverse disciplines to work together, but there was a disconnect between knowledge generation and translation of that knowledge into action. Although the above examples have a health focus, inadequate research integration is evident in all complex problem areas, such as those focused on environmental degradation, racism and security in civil society (Bammer 2013).

3.1.3 Research Translation or Implementation

As noted above, knowledge should not only be integrated across disciplines, but also implemented across societal sectors. Unfortunately, even researchers who incorporate multiple disciplinary perspectives may overlook the need to engage with beneficiaries and stakeholders across sectors (Neuhauser et al. 2007). As a result, there is ample evidence that even when we have excellent evidence-based research that addresses the main determinants of a problem, we may not be able to translate that science into practical strategies that people can adopt in their social contexts. Jensen (2003) estimates that interventions rarely reach more than 1% of their target populations. Another review concludes that it may take 17 years to turn 14% of original health research into clinical applications (Balas and Boren 2000), and the time it would take for basic research to have an impact at the community or population level would be even longer.

An example is that research overwhelmingly shows that vaccinations significantly prevent disease. However, significant numbers of people globally still lack access to vaccines, or choose not to get vaccinated for cultural, religious or economic reasons. A better way to address the uptake of vaccinations is to engage health practitioners and policymakers—as well as the diverse groups of people to be vaccinated—to identify issues and solutions with the goal of creating the most effective strategies.

Since the end of the twentieth century, the "social-ecological model" (Stokols 2006) has become a widely used framework to guide researchers, practitioners and policymakers in translating scientific findings into effective interventions. This model illustrates interacting levels of society ranging from individuals, families, neighborhoods/communities, and organizations to the broadest cultural, political, environmental influences. Those who research problems, and those who develop and implement interventions, are urged to take into account each of these levels and their interactions. By the late twentieth century, models of research translation or dissemination had emerged as a way to fill the knowledge–action gap. Knowledge dissemination can be defined as "an active and strategically planned process whereby new or existing knowledge, interventions, or practices are spread" (Kiefer et al. 2005, p. I–14). As with first generation research integration models, the early research translation/dissemination models assumed a two-step process in which researchers would conduct research and then professionals would implement strategies based on that research. This disconnected approach, and its frequently unsuccessful results, were widely critiqued—motivating a move towards transdisciplinary models, as described below.

3.1.4 Participation

A third key weakness of traditional "research for action" approaches is the lack of intense participation on the part of researchers, practitioners, policymakers and beneficiaries. Inadequate participation affects all aspects of research integration and research implementation (Neuhauser and Kreps 2014; Minkler and Wallerstein 2008). In research integration, lack of participation among researchers from an adequate number of disciplines makes it harder to get to the root causes of problems and create successful interventions. Likewise, for research translation or implementation, lack of participation from members of relevant societal sectors results in ineffective interventions. And, for both research integration and implementation, traditionally there has been weak participation from the end users—those intended to benefit from an intervention may not be adequately involved in its design or implementation. Often "user participation" is limited to focus groups or other kinds of feedback about interventions which have already been designed, rather than true collaboration from the start.

Over the past 60 years, theories and methods of participatory design have emerged from a number of disciplines in the social sciences (sociology, public health, etc.) and in the socio-technical or "design" sciences (engineering, architecture etc.) (Neuhauser and Pohl 2014; Neuhauser et al. 2013a). In the social sciences, the aforementioned social-ecological models emphasize the participation of all actors involved in researching, implementing and benefitting from interventions. Scholars commented on the tension between the agendas of investigators (with their researcher-created models) and the collaborative work of many stakeholders to create knowledge and action to benefit society. This prompted sociologist Kurt Lewin to develop the concept of "action research" in 1946, which he describes as "comparative research on the conditions and effects of various forms of social action and research leading to social action" (p. 25) that uses "a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action" (p. 38).

Action research and community-based participatory research models emphasize reciprocal cycles of "research for action" and "action for research". They provide important guidance on strategies to promote collaboration between researchers, implementers, beneficiaries and other stakeholders (Reason and Bradbury 2008; Minkler and Wallerstein 2008). Action research, especially community-based participatory action research, generally involves long-term processes of community–researcher engagement, problem identification, reflection, and the development of interventions, followed by implementation and revision.

3.2 Transdisciplinarity: A Unified Concept to Address Complex Problems

Since in the 1970s, there has been a movement toward research for action models that combine research integration across disciplines and across sectors with the intensive collaboration of all stakeholders. The emergence of integrated biological, social and ecological frameworks, and the emergence of complexity and systems theories, has had a significant influence on the shift to the use of highly integrated applied research to solve complex problems (Bammer 2013; Neuhauser and Pohl 2014). This shift reflects the newer view that knowledge is tightly woven within priorities, cultures and contexts, and that phenomena should be studied in varied and dynamic real-world contexts, rather than under controlled conditions (Green and Glasgow 2006). Examples of health- and social issue-related models that encompass complexity across time, place and culture, and that advocate highly collaborative processes, include: Stokols (2006), Sussman et al. (2006), and Bammer (2013). Transdisciplinarity has evolved as the concept best able to enable research integration and implementation across disciplines and societal sectors, and to combine them with intense participatory processes. Philosopher and educator Jean Piaget is credited with introducing the term "transdisciplinarity" (Nicolescu 2002).

There are multiple definitions and models of transdisciplinarity as described by contributors to this book (Gibbs et al. 2018, Chap. 1 in this book; Klein 2018, Chap. 2 in this book; Ross and Mitchell 2018, Chap. 4 in this book; Prior et al. 2018, Chap. 5 in this book; Nicolescu 2018, Chap. 6 in this book) and elsewhere (Klein 2010; Gibbs 2014; Hadorn et al. 2010; Hoffman-Reim et al. 2008; Nicolescu 2002; Nicolescu 2010).

Jahn, Bergmann and Keil (2012: 4) proposed the following definition:

> Transdisciplinary is a reflexive research approach that addresses societal problems by means of interdisciplinary collaboration as well as the collaboration between researchers and extra-scientific actors. Its aim is to enable mutual learning processes between science and society; integration is the main cognitive challenge of the research process.

Pohl and Hirsch Hadorn's definition (2007: 20) is problem-focused:

> The starting point for transdisciplinary research is a socially relevant problem field. Within this field, TR identifies, structures, analyses, and deals with specific problems in such a way that it can:
>
> (a) grasp the complexity of problems,
> (b) take into account the diversity of life-world and scientific perceptions of problems,
> (c) link abstract and case-specific knowledge, and
> (d) develop knowledge and practices that promote what is perceived to be the common good.
>
> Participatory research and collaboration between disciplines are the means of meeting requirements (a–d) in the research process.

Transdisciplinary models address the key weaknesses of traditional research integration, translation/implementation and participation. Transdisciplinary work is characterized by highly participatory, mixed (quantitative and qualitative) methods that engage researchers and professionals from multiple disciplines and societal sectors, including those intended to benefit for interventions. These stakeholders are involved from the beginning and continuously rather than in disconnected phases. Although some interdisciplinary and transdisciplinary models overlap, transdisciplinary approaches typically go beyond interdisciplinary input; they involve a "transcendent" approach in which the collaborators create a common definition of a problem that goes beyond those found in their disciplines, and even new paradigms and methods for real-world problem-solving. Transdisciplinary theory and methods are rapidly evolving and are drawn from all disciplines. Since the beginning of this century, evidence-based research and case reports have been providing rich guidance for those involved in this work. For example, studies examining the "science of team science" (Stokols 2006) highlight the importance of the personal skills, collaborative techniques and institutional support needed for successful transdisciplinary science and action (Stokols et al. 2005; Kahn and Prager 1994; Cruz et al. 2015; Bammer 2013; Neuhauser and Pohl 2014; Neuhauser et al. 2007).

3.3 The Scientific Foundation of Transdisciplinarity

The last section describe have described the practical, empirical challenges of addressing complex problems, and how these challenges acted as a catalyst for a shift away from approaches which attempt to integrate disconnected approaches to research and implementation, and towards unified, robust transdisciplinary models of research and action. However, critics sometimes argue that transdisciplinary research and its implementation lacks the firm grounding in theory and methods that is afforded by working within specific, well-developed disciplines. This section desscribes the equally important transformation in perspectives about ontology (the study of reality) and epistemology (ways of studying knowledge) that provide a strong scientific foundation for transdisciplinary models.

3.3.1 Changes in Scientific Thinking About Ontology

Although the deepest roots of transdisciplinary thought and action can be traced back thousands of years, beginning with early philosophers (Gibbs 2018, Chap. 19 in this book) the concept of transdisciplinarity emerged in the mid-twentieth century, not only as a response to the practical concerns of scientists and other stakeholders, but also as part of a major shift in scientific paradigms. The so-called scientific revolution was prompted by perceived weaknesses in scientific inquiry and its application to societal problems (Kuhn 1962). Scholars moved away from the view that only one reality exists, and that it is knowable.

For example, Deleuze and Guattarti (1980) critique the accepted Western view that the world is characterized by an essential coherence or "whole" made up of its components, and that this world is governed by laws and has evolved linearly. Their view is that reality is made up of multiple dimensions (or directions in motion) with neither a beginning nor an end. They use the analogy of the Internet which has no centre, but rather an infinite number of links. Nicolescu further comments that because there are multiple levels of reality governed by different types of logic, reducing complex phenomena to a single (ontological) level governed by a single form of logic limits the potential of researchers to successfully address social problems (Nicolescu 2004). Similarly, Cook (1985) argues that reality is complex, contextual, and ever changing. As a result, understanding occurs through examining heterogeneous "multiplicities" as they spread and interact. Increasingly, scholars argue that transdisciplinary thinking and inquiry are the best fit for this new, complex and dynamic view of reality. As Nicolescu (2004: 48) comments, transdisciplinary thinking assumes that "everything is dependent on everything else, everything is connected; nothing is separate,"—including thinking from many disciplines.

3.3.2 Changes in Thinking About Epistemology

As thinking about ontology underwent a major transformation beginning in the mid-twentieth century, so did thinking about epistemology. In this new perspective, knowledge is "collective" and cannot be found through any single discipline (Kahn and Prager 1994). And, according to Cook (1985), creating knowledge requires that multiple investigators and stakeholders gradually study phenomena from as many different perspectives as possible, using multiple theoretical frameworks, methods, settings and interpretations of evidence. This is a concept known as "critical multiplism." As mentioned above, changes in scientific inquiry were also prompted by an increasing interest in addressing complex, or "wicked" problems. Such problems are typically heterogeneous, changeable, contextually localized, value-laden, sometimes caused by those charged with addressing them, and difficult to understand and solve (Rittel and Webber 1973; Brown et al. 2010; Tapio and Huutoniemi 2014; Buchanan 1992; March and Smith 1995). Another challenging aspect of these problems is that they cannot be well defined until after they have been studied. Finally, because of their complexity and changeability, such problems must be constantly redefined and re-studied over time. Health and social problems are almost always wicked problems.

3.3.3 Human Sciences: The Second Epistemological Paradigm

The new perspectives about reality and knowledge presented major challenges to traditional ways of studying them. Until the mid-twentieth century, the dominant epistemological paradigm was positivist. It assumed that the world is knowable and governed by universal laws, and that knowledge can be generalized to multiple settings. Although this approach to scientific inquiry worked fairly well for the natural sciences, such as physics and chemistry, it became clear that such a paradigm was inadequate for studying phenomena affected by human behaviour. This led to the emergence of the second major epistemological paradigm in the "human (or, interpretive) sciences," such as sociology, anthropology (Dilthey 1988). This paradigm acknowledges that because human phenomena are not as predictable as those in the natural sciences, they must be studied using multiple methods in many settings (Cook 1985).

3.3.4 Design Science: The Third Epistemological Paradigm

The emergence of the human/interpretivist paradigm revolutionized scientific inquiry, but a question still remained: How can we study the process of designing the future? Although this question may seem nonsensical at first, it is actually a highly practical problem that affects many human endeavours, such as designing a building or a health programme in a way that provides a high probability of success. To meet this challenge, architect Buckminster Fuller (1963) coined the term "design science," now considered the third major epistemological paradigm. Design sciences, or "sciences of the artificial" are concerned "not with how things are, but with how they might be" (Simon 1996: 4). In the design sciences, researchers study human-created (artificial) objects and phenomena intended to solve problems and meet goals. These artifacts can be symbols, material objects, activities, services (such as a health programme), learning environments or living environments (Buchanan 1992).

Design science also emerged as an explicit way to study and address the aforementioned wicked problems—a major issue for those of us who, in planning interventions, are faced with an array of ever-changing problems and options for solutions. The early writing about this paradigm focused on its utility in architecture and engineering (Fuller and McHale 1963; Rittel and Webber 1973; March and Smith 1995). For that reason, formal design science fields are concentrated in engineering, information systems, architecture, computer science and other primarily "socio-technical" fields. However, design science guidance is now being rapidly adopted in many social science, natural science, business, policy and other fields.

In terms of axiology, or the "study of values," the design science paradigm differs significantly from the other two major epistemological paradigms. In the positivist/natural science paradigm, the goal (and value) is truth—reflected in the emphasis on formulating predictive hypotheses before research begins. In the design science paradigm, the goal is the utility of the solution to meet a need. The fundamental question is: Does it work? (Vaishnavi and Keuchler 2012; Gregg et al. 2001; Guba and Lincoln 1994). We note that one important area of epistemological overlap between design science and the human sciences is that of "action research and community-based participatory research" mentioned earlier. In these action research models, the primary goal is to create a solution for a particular problem or group of beneficiaries, rather than to make predictions or test a theory.

3.3.5 Changes in Epistemological Methods

The expansion of epistemological paradigms over the past 70 years has not only provided rich theoretical guidance, but also an increasing number of methods to study phenomena and design for the future. In the natural sciences, methods are primarily experimental and quantitative, and research is conducted under controlled conditions, such as randomized, controlled trials. In the human sciences, both quantitative methods such as surveys, and qualitative methods such as in-depth interviews, are used. Because the goal of design science inquiry is to solve problems rather than to test theories, design science methods are highly participatory, qualitative, inductive and iterative (March and Smith 1995).

Novel design science methods include usability testing, in which researchers observe and gather in-depth, in-person information from users testing a prototype (such as a computer programme, a medical training programme, or a health communication resource (Nielsen 2000; Rubin and Chisnell 2008; Neuhauser et al. 2013a, b). Usability testing and revisions continue over multiple rounds until the prototype meets the desired specifications of the intended users. Another popular method from the design sciences is "design thinking," a highly interactive rapid process in which users and diverse stakeholders get together to define problems and options for solutions in the same session. This method was developed by the Stanford University Hasso Plattner Institute of Design ("d.school": https://dschool.stanford.edu/). It was used to design Apple computers and phones, and many other products as well as to address social issues. Design science methods use "problem and solution" and "build and design" loops as illustrated in Fig. 3.1 (Roschuni 2012)

In the problem development cycle in Fig. 3.1, data are gathered from users and other sources using qualitative methods, then analyzed and used to define problems

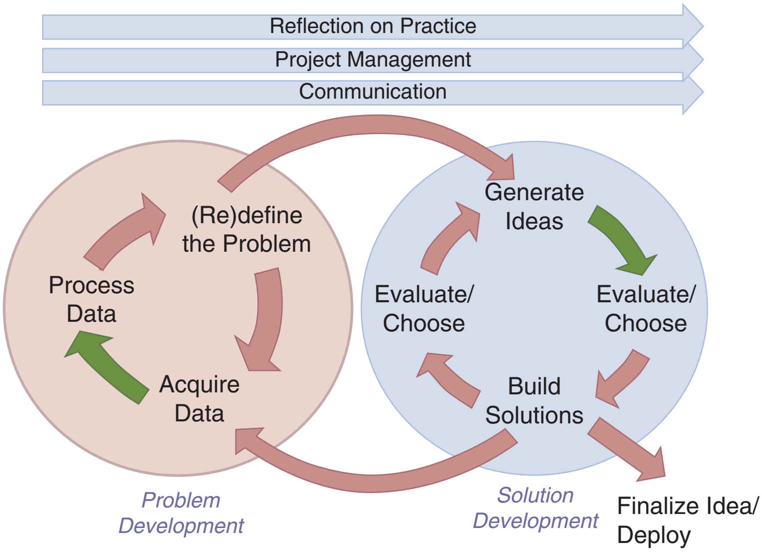

Fig. 3.1 The general design process (Roschuni 2012). (Reproduced by permission of Celeste Nicole Roschuni)

and needs. In the solution development cycle, ideas are generated to build and test prototypes in collaboration with users. Iterative feedback loops are used within and between the cycles. Although there is no theoretical end to the process of identifying problems and solutions, there is a point where researchers and developers finalize and deploy a solution when it reaches the users' key specifications.

This process is very different from the traditional process in which researchers define problems, formulate hypotheses, define methods and predict outcomes *before* conducting research—such as in writing a proposal for funding (Guba and Lincoln 1994; Neuhauser et al. 2013a, b). In the design science approach, researchers, users and stakeholders are considered equals and participate in an iterative process to identify problems and possible solutions, and to test and revise prototype solutions. As mentioned above, the epistemological goals of human/interpretive sciences and design science overlap in the area of action research and community-based participatory research, and so do the methods.

For example, a community action project may use traditional human/interpretive science methods such as focus groups and in-depth interviews. Likewise, design science methods such as design thinking and the usability testing of prototype solutions may be added to this effort. And, some projects which are primarily design projects may borrow methods from all three paradigms. For example, an effort to design effective health communication information for older adults and people with disabilities in California (USA) combined multiple methods from the three paradigms, including focus groups, surveys, in-depth interviews, usability testing and a randomized, controlled trial (Neuhauser et al. 2009; Kurtovich et al. 2009). We note that randomized, controlled trials are an example of a method involving a priori hypotheses (common to the positivist and human/interpretive sciences paradigms) and, in this case, they were conducted after the health communication resource was designed using a primarily design science/action research approach. This ability to borrow theory and methods from all three paradigms—with a special emphasis on incorporating those from design science in early stages—is critical for addressing complex problems.

3.4 Transdisciplinarity and Changed Epistemological Paradigms and Methods

Just as transdisciplinary science is the area of study that has the best fit with new perspectives about reality, it is also the most aligned with transformed epistemological theory and methods of creating and applying knowledge. McGregor (2014) and Nicolescu (2004) argue that transdisciplinarity is characterized by multiple, constantly changing realities, in which multiple and contradictory perspectives can be temporarily joined in the search for knowledge. To join these perspectives, people from academia and civil society need co-create knowledge using an emergent, iterative process. Knowledge produced in this way will be complex, emerging and constantly reorganized, rather than static and discipline-bound (McGregor 2014). As Hoffman-Reim and colleagues (2008: 4) commented: "Transdisciplinary orientations in research, education and institutions try to overcome the mismatch between knowledge production in academia, on the one hand, and knowledge requests for solving societal problems, on the other." Although all epistemological frameworks and methods provide useful guidance for solving complex problems, we suggest that it is especially useful for researchers, practitioners and other stakeholders to incorporate design science thinking and methods into their work.

3.5 Conclusion

Long-standing concerns about how to address complex problems led to the strong movement toward collaborative research and action across diverse disciplines and societal sectors—or transdisciplinarity. In parallel, the transformation of thinking about reality, and ways of studying reality, provided a sound scientific foundation which supports transdisciplinarity. Successful transdisciplinary work requires drawing on theory and methods in all scientific paradigms and the intense participation of stakeholders. Guidance and methods from design science are especially helpful for iteratively planning and refining complex interventions. It is also new to many of us in the health, social and environmental sciences who have been trained in more traditional methods. Increasingly, studies are documenting the effectiveness of transdisciplinary work. For example, Chap. 15 in this book, "Collaborative research and action: The Changzhou Worker Wellness Project," is a companion case study to this theoretically-focused chapter. The case study illustrates the challenges, strategies and successes of applying the transdisciplinary theory and methods described in this chapter to address the highly complex problem of supporting Chinese migrant factory workers. Similarly, the chapters in parts II and III of this book highlight the value of transdisciplinarity for teaching and societal action.

References

Balas, E. A., & Boren, S. A. (2000). Managing clinical knowledge for health care improvement. In J. H. Van Bemmel & A. T. McCray (Eds.), *IMIA yearbook of medical informatics* (pp. 65–70). Stuttgart: Schattauer.

Bammer, G. (2013). *Disciplining interdisciplinarity: Integration and implementation sciences for researching complex real-world problems*. Canberra: Australian National University Press Available at: http://epress.anu.edu.au/titles/disciplining-interdisciplinarity/pdf-download.

Best, A., Hiatt, R. A., & Norman, C. (2006). *The language and logic of research transfer: Finding common ground* (Report). Working Group on Translational Research and Knowledge Integration, National Cancer Institute of Canada, Toronto, Canada.

Brown, V. A., Harris, J. A., & Russell, J. Y. (2010). *Tackling wicked problems through the transdisciplinary imagination*. London: Earthscan.

Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues, 8*, 5–21.

Cook, T. (1985). Post positivist critical multiplism. In R. Shotland & M. Mark (Eds.), *Social science and social policy* (pp. 25–62). Beverly Hills: Sage.

Cruz, P., Fernandez, V., Lorieto, A., Repetto, L., Vinenni, B., & Von Sanden, C. (Eds.). (2015). *En_Clave Inter: Interdisciplina, instituciones y politicaspublicas*. Espacio Interdiscipinario de la Universidad de la República, Uruguay (pp. 35–47). Montevideo: Mastergraf Publishing.

Deleuze, G., & Guattari, F. (1980). *A thousand plateaus* (B. Massumi, Trans.). London/New York: Continuum. 2004. Vol. 2 of Capitalism and Schizophrenia. 2 vols. 1972–1980. Trans. of Mille Plateaux. Paris: Les Editions de Minuit.

Dilthey, W. (1988). *Introduction to the human sciences*. Detroit: Wayne State University Press.

Fuller, R. B., & McHale, J. (1963). *World design science decade, 1965–1975*. Carbondale: Southern Illinois University.

Gibbs, P. T. (Ed.). (2014). *A transdisciplinary study of higher education and professional identity*. New York: Springer.

Green, L. W., & Glasgow, R. E. (2006). Evaluating the relevance, generalization, and applicability of research: Issues in external validation and translation methodology. *Evaluation and the Health Professions, 29*(1), 126–153.

Gregg, D., Kulkarni, U., & Vinze, A. (2001). Understanding the philosophical underpinnings of software engineering research in information systems. *Information Systems Frontiers, 3*(2), 169–183.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The handbook of qualitative research* (pp. 105–117). Thousand Oaks: Sage.

Hadorn, H. G., Pohl, C., & Bammer, G. (2010). Solving problems through transdisciplinary research. In R. Frodeman, J. Thompson Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 431–452). Oxford: Oxford University Press.

Halfon, N., & Hochstein, M. (2002). Life course health development: An integrated framework for developing health, policy, and research. *Milbank Quarterly, 80*(3), 433–479.

Hoffman-Reim, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Hadorn, G. H., Joye, D., Pohl, C., et al. (2008). Idea for the handbook. In G. H. Hadorn, H. Hoffman-Reim, S. Biber-Klemm, W. Grossenbacher-Mansuy, G. H. Hadorn, D. Joye, C. Pohl, et al. (Eds.), *Handbook of transdisciplinary research* (pp. 3–18). London: Springer.

Jahn, T., Bergmann, M., & Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics, 79*, 1–10.

Jensen, P. S. (2003). Commentary: The next generation is overdue. *Journal of the American Academy of Adolescent Psychiatry, 42*(5), 527–530.

Kahn, R. L., & Prager, D. J. (1994). Interdisciplinary collaborations are a scientific and social imperative. *The Scientist, 17*, 11–12.

Kiefer, L., Frank, J., Di Ruggerio, E., Dobbins, M., Manuel, D., Gully, P. R., et al. (2005). Fostering evidence-based decision-making in Canada: Examining the need for a Canadian population and public health evidence centre and research network. *Canadian Journal of Public Health, 96*(3), I1–I19.

Klein, J. T. (2010). A taxonomy of interdisciplinary knowledge. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 15–30). Oxford: Oxford University Press.

Kuhn, T. S. (1962). *The structure of scientific revolutions* (1st ed.). Chicago: University of Chicago Press.

Kurtovich, E., Ivey, S., Neuhauser, L., & Graham, C. (2009). Evaluation of a multilingual mass communication intervention for seniors and people with disabilities on Medicaid: A randomized controlled trial. *Health Services Research*. https://doi.org/10.1111/j.1475-6773.2009.01073.

Lewin, K. (1946). Action research and minority problems. *Journal of Social Issues, 2*(4), 34–46. https://doi.org/10.1111/j.1540-4560.1946.tb02295.x.

Lubchenco, J. (1998). Entering the century of the environment: A new social contract for science. *Science, 279*(5350), 491–497.

March, S., & Smith, G. (1995). Design and natural science research on information technology. *Decision Support Systems, 15*(4), 251–266.

McGregor, S. L. (2014). Nicolescuian transdisciplinary as an educative process. In P. T. Gibbs (Ed.), *A transdisciplinarity study of higher education and professional identity*. New York: Springer.

Minkler, M., & Wallerstein, N. (Eds.). (2008). *Community based participatory research for health: Process to outcomes* (2nd ed.). San Francisco: Jossey-Bass.

Neuhauser, L., & Kreps, G. L. (2014). Integrating design science theory and methods to improve the development and evaluation of health communication programs. *Health Communication., 19*(12), 1460–1471. https://doi.org/10.1080/10810730.2014.954081.

Neuhauser, L., & Pohl, C. (2014). Integrating transdisciplinary and translational concepts and methods into graduate education. In P. T. Gibbs (Ed.), *A transdisciplinary study of higher education and professional identity*. New York: Springer.

Neuhauser, L., Richardson, D., Mackenzie, S., & Minkler, M. (2007). Advancing transdisciplinary and translational research practice: Issues and models of doctoral education in public health. *Journal of Research Practice, 3*(2), Article M19 Available at: http://jrp.icaap.org/index.php/jrp/article/view/103/97.

Neuhauser, L., Rothschild, B., Graham, C., Ivey, S., & Konishi, S. (2009). Participatory design of mass health communication in three languages for seniors and people with disabilities on Medicaid. *American Journal of Public Health, 99*, 2188–2195.

Neuhauser, L., Kreps, G. L., Morrison, K., Athanasoulis, M., Kirienko, N., & Van Brunt, D. (2013a). Using design science and artificial intelligence to improve health communication: Chronology MD case example. *Patient Education Counsel, 92*(2), 211–217.

Neuhauser, L., Kreps, G. L., & Syme, S. L. (2013b). Community participatory design of health communication programs: Methods and case examples from Australia, China, Switzerland and the United States. In D. K. Kim, A. Singhal, & G. L. Kreps (Eds.), *Global health communication strategies in the 21st century: design, implementation and evaluation*. New York: Peter Lang Publishing.

Nicolescu, B. (2002). *Manifesto of transdisciplinarity* (K.-C. Voss, Trans.). Albany: State University of New York Press.

Nicolescu, B. (2004). Gurdjieff's philosophy of nature. In J. Needleman & G. Baker (Eds.), *Gurdjieff* (pp. 37–69). New York: The Continuum International Publishing Group.
Nicolescu, B. (2010). Methodology of transdisciplinarity – Levels of reality, logic of the included middle and complexity. *Transdisciplinary Journal of Engineering & Science, 1*(1), 19–38.
Nielsen, J. (2000). *Designing web usability*. Indianapolis: New Riders.
Phelan, J. C., Link, B. G., & Tehranifar, P. (2010). Social conditions as fundamental causes of health inequalities. *Journal of Health and Social Behavior, 51*(1 suppl), S28–S40.
Pohl, C., & Hadorn, G. H. (2007). *Principles for designing transdisciplinary research* (A. B. Zimmerman, Trans.). Munich: OEKOM.
Reason, P., & Bradbury, H. (Eds.). (2008). *The Sage handbook of action research: Participative inquiry and practice*. London/Thousand Oaks: Sage.
Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*(2), 155–169.
Roschuni, C. N. (2012). *Communicating design research effectively*. Ph.D dissertation, 2012. Retrieved from http://escholarship.org/uc/item/75f0z49v?query=roschuni.
Rubin, J., & Chisnell, D. (2008). *Handbook of usability testing*. Indianapolis: Wiley Publishing.
Rubio, D. M., Schoenbaum, E. E., Lee, L. S., Schteingart, D. E., Marantz, P. R., Anderson, K. E., Platt, L. D., Baez, A., & Esposito, K. (2010). Defining translational research: Implications for training. *Academic Medicine, 85*(3), 470–475.
Simon, H. (1996). *The sciences of the artificial* (3rd ed.). Cambridge, MA: MIT Press.
Smedley, B. D., & Syme, S. L. (2000). *Promoting health: Intervention strategies from social and behavioral research, Institute of Medicine*. Washington, DC: National Academies Press.
Stokols, D. (2006). Toward a science of transdisciplinary research. *American Journal of Community Psychology, 38*, 63–77.
Stokols, D., Harvey, R., Gress, J., Fuqua, J., & Phillips, K. (2005). In vivo studies of transdisciplinary scientific collaboration: Lessons learned and implications for active living research. *American Journal of Preventive Medicine, 28*(Suppl. 2), 202–213.
Sussman, S., Valente, T. W., Rohrbach, L. A., Skara, S., & Pentz, M. A. (2006). Translation in the health professions: Converting science into action. *Evaluation and the Health Professions, 29*(1), 7–32.
Tapio, P., & Huutoniemi, K. (Eds.). (2014). *Transdisciplinary sustainability studies: A heuristic approach*. New York: Routledge.
Vaishnavi, V., & Keuchler, B. (Section Editors). (2012). *Design science research in information systems*. Accessed August 2017 at: http://desrist.org/desrist/content/design-science-research-in-information-systems.pdf.
Whitehead, M. (1991). The concepts and principles of equity and health. *Health Promotion International, 6*(3), 217–228.
Wilkinson, R., & Marmot, M. (Eds.). (2003). *The solid facts* (2nd ed.). Geneva: World Health Organization.
Woolf, S. H. (2008). The meaning of translational research and why it matters. *Journal of the American Medical Association, 299*(2), 211–213.

Chapter 4
Transforming Transdisciplinarity: An Expansion of Strong Transdisciplinarity and Its Centrality in Enabling Effective Collaboration

Katie Ross and Cynthia Mitchell

4.1 Introduction

This chapter expands and enriches existing *characterisations* and *premises* of strong transdisciplinarity in order to develop the concept of Transforming Transdisciplinarity. By introducing the concepts of 'strong' and 'weak' transdisciplinarity, Manfred Max-Neef sought to increase the effectiveness of collaborative transdisciplinary efforts (2005). Strong transdisciplinarity, as articulated by Max-Neef, is one in which learning facilitates an onto-epistemological shift among a group of collaborative researchers from linear and reductive logic toward a more complex view of realities. The onto-epistemological shift required for Max-Neef's strong transdisciplinarity is analogous to Einstein's suggestion that new ways of thinking are required if we are to solve the wicked complexities of what we have created.

The discussion of weak and strong transdisciplinary in the academic literature to date has focused on ontology and epistemology (Max-Neef 2005; Nicolescu 2002). In this chapter, we discuss the predecessors to Max-Neef's articulations of strong transdisciplinarity: Erich Jantsch and Basarab Nicolescu. Interpreting the primary texts of these three authors, we first question whether the definition of strong transdisciplinarity should be expanded to include both Jantsch's axiological and Nicolescu's onto-epistemological visions. Secondly, based on a brief review of how the concept of strong transdisciplinarity is used in the current literature, we argue for the benefits of more thoroughly articulating the premise upon which strong transdisciplinarity is based. That premise is a sharp critique of the Cartesian-Newtonian paradigm. In order to strengthen this premise, we review additional theoretical orientations noted by Nicolescu, Max-Neef and Jantsch as relevant to

K. Ross (✉) · C. Mitchell
Institute for Sustainable Futures, University of Technology Sydney, Sydney, NSW, Australia
e-mail: katie.ross@uts.edu.au

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_4

Table 4.1 A selection of supporting theoretical orientations of strong transdisciplinarity

Theoretical orientations linked to strong TD	Examples of people reviewed
Systems/complexity	Edgar Morin, Fritjof Capra, Stuart Kauffman
Indigenous/eastern perspectives	Joanna Macy, Aluli-Meyer, MJ Barrett
Experiential learning (*integration of reason, feeling, action*)	Paulo Freire, John Dewey

transdisciplinarity (listed in Table 4.1; note, while they mentioned these theoretical orientations, they did not mention all of these authors by name).

What becomes apparent during this analysis of transdisciplinary-oriented theorists are shared critiques of the Cartesian-Newtonian paradigm that overlap in the six meaning systems of societal paradigms and individual worldviews: cosmologies, ontologies, epistemologies, axiologies, anthropologies, and social visions. We argue that in order for transdisciplinarity to be truly transformative, collaborative researchers should provide the space for collective, third order learning around these meaning systems. Third order learning is a process during which learners experience paradigmatic reconstruction or paradigmatic stretching (Sterling 2010), which we argue is the intention of Transforming Transdisciplinarity.

4.1.1 Why Is Transforming Transdisciplinarity Needed?

Societies are faced with the gargantuan task of creating a safe and just operating space for humanity, today and into the future (Steffen et al. 2015; Raworth 2017). Researchers, governments, business, communities and schools are collaborating to *mitigate* and *adapt* to planetary boundary overshoot (Rockström et al. 2009) and to achieve the United Nations Sustainable Development Goals, for all. The complexity of this task is exacerbated by the arrival of the Anthropocene. The designation of our current geologic time period as the Anthropocene acknowledges that humans have become the most influential force in driving the Earth's systems. Whereas the last 10,000 years of a relatively stable climate in the Holocene allowed humanity to flourish, the human activity drivers in the Anthropocene are pushing the Earth's operating systems into completely new and unpredictable states (Lewis and Malsin 2015).

The Anthropocene, planetary boundary overshoot and challenges in realising human rights across the globe, are powerful imperatives for effective, collaborative transdisciplinary research. In fact, these wicked problems provided the original impetus for developing transdisciplinarity (Jantsch 1970; Nicolescu 2002; Max-Neef 2005). However, only weak transdisciplinarity occurs as long as we remain within the scope of linear logic, which is characteristic of the Western, or more specifically the Cartesian-Newtonian paradigm (defined below) (Max-Neef 2005). This chapter expands Rittel and Webber's (1973) argument that wicked problems manifest from, and are driven by, the linear logic of the Cartesian-Newtonian paradigm. We set out the arguments for why a different paradigm is necessary to effectively grapple with the human and biophysical challenges we face. We argue that this shift requires a different paradigm of transdisciplinarity—Transforming Transdisciplinarity. Whilst we recognise the contributions of the Cartesian-Newtonian paradigm, our intention is to begin an articulation of an integrated vision for Transforming Transdisciplinarity. In doing so, we remain mindful of Morin's guidance to critique and transcend any paradigm, since every paradigm has truths and benefits, as well myths and rationalisations (2001).

Here, we define a *paradigm* as a culturally or socially shared set of beliefs, values, prioritised concepts, and rules of logic for interpreting and making sense of the world (Kuhn 1996), contrasted with *worldview* as an individual's beliefs, concepts and logic (Hedlund-de Witt et al. 2014).

If the driving force behind the Anthropocene and wicked problems that we face today (Rittel and Webber 1973) is the Cartesian-Newtonian paradigm's inability to grasp complexity, what does this mean for our experiences of collaboration and collective learning? ***At one level***, collaboration is addressing *hyper-specialisation*. Hyper-specialisation could be seen as an example of a root driver of unsustainability arising from the Cartesian-Newtonian paradigm's reductive approach to understanding the world (Max-Neef 2005). Gaps in our understanding are addressed by breaking issues into smaller components, and removing them from their contexts for study. Our global and planetary problems are bigger than the sense-making power of any single discipline, culture, worldview, mythic structure or paradigm (Max-Neef 2005), making collaboration necessary. However, and this is a key point for our argument, collaboration within the same paradigm risks overlooking the meaning systems or mythic frameworks driving our wicked problems (Table 4.2), inadvertently creating a reinforcing feedback loop (shown as R in Fig. 4.1).

Alternatively, collaborating researchers could practice reflexively, and include their paradigms within the boundaries of analysis and reflection. Collective reflection on and exploration of the relationship between our individual worldviews and our arrival in the Anthropocene holds the potential to access ***another, deeper level*** for collaboration, creating a balancing feedback loop (shown as B in Fig. 4.1) of *Transforming Transdisciplinarity*.

4.2 How Has the Concept of Strong Transdisciplinarity Been Defined and Used?

4.2.1 The Intellectual Lineage of Strong Transdisciplinarity

In this section, we trace and provide a re-interpretation of the lineage of strong transdisciplinarity. We begin with Erich Jantsch (1970, 1972) because Max-Neef and Nicolescu do so. Max-Neef's 'weak transdisciplinary' structures are strikingly similar to Jantsch's (1970) constructs (or as Buchanan (2016) suggests, potentially reprinted without explicit recognition). Nicolescu notes and adopts Jantsch's call for an axiomatic approach. Max-Neef uses Nicolescu as the basis for his 'strong transdisciplinarity'.

Table 4.2 The defining beliefs of the Cartesian-Newtonian paradigm mapped to six meaning systems

Meaning system	Definition of system (e.g. beliefs of:)	Beliefs and embedded assumptions in the Cartesian-Newtonian paradigm
Cosmology Capra (1982), Blackburn (1971), and Montuori (2017)	Origins of the universe	The universe is a giant predictable machine, which is not influenced by time (meaning the laws of physics can accurately predict the future and the past).
Ontology Dewey (1910) and Nicolescu (2014)	How we define reality	Reality is defined by *absolute permanency*, in which forms are fixed and completely ordered. Nature is deterministic, governed by causal laws.
Epistemology Dewey (1938/1963), Darder (2015, p. 14), Morin (2001, 82), Garrison et al. (2012, p. 41), Sunde (2008), Kolb (2015, p. 85), Capra (1982, p. 23, 40), and Blackburn (1971)	Knowledge (truth claims), knowing, and understanding (grasped meaning)	Knowledge is a finite, unchanging, universal product, contained within the brain, and disconnected with personal and historical experience. Rationality and reason are separate from and superior to experience and emotion. Reductionism is a primary method for understanding phenomena.
Axiology Dewey (1933/1998), Macy (1991, p. 104), Jantsch (1970), Nicolescu (2006), Abson et al. (2017) and Rittel and Webber (1973)	Values and how we value	Value is separate from, and has no place in, objective thought. It is possible to separate values from knowing, and from the means of achieving our ends.
Anthropology Capra (1982, p. 23), Jantsch (1970), and Blackburn (1971)	The role of humanity	The role of humanity, and specifically human reason, is to predict and control nature, in order to achieve our end of "progress". Humans are separate from and superior to nature.
Social vision Dewey (1938/1963) and Darder (2015, p. 23)	How society should be organised	Democracy and capitalism are superior forms of social organisation.

4.2.2 Beginning with Jantsch

Jantsch argues for a restructure of education and innovation systems towards transdisciplinarity (coordination of the whole system toward a common goal) in order to more effectively address societal challenges and improve societal renewal (1970, 1972). Jantsch proposes restructuring these systems as interacting and mutually benefitting stratifications:

- an empirical level (natural sciences which create meaning through logic)
- a pragmatic level (more explicitly subjective sciences which create meaning through interrelations and feedback/control)
- a normative level (broader social-economical-technological-institutional systems which create meaning through planning)

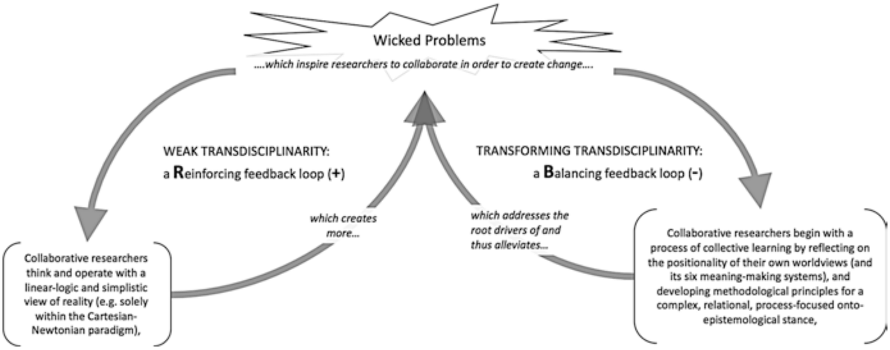

Fig. 4.1 The impact of reinforcing versus balancing feedback loops in collaboration, in regards to addressing the root causes of wicked problems

- a purposive level (philosophical questions which create meaning through values and, more specifically, ultimate human/nature survival).

Jantsch envisions this integrated system as being guided explicitly and purposively by our axiology—our paradigmatic meaning system of values. He argues this feedback between our "anthropomorphic meaning" (i.e. our axiology) and our social systems design (i.e. our transdisciplinary research) is an important matter for human survival (1970, 1972). Almost 40 years before the Anthropocene was formally recognised, Jantsch identified humans as the chief actors in shaping and degrading our enviro-social systems: "*Is it not becoming increasingly clear that man, through science and technology, has become the principal cybernetic* [governing] *'actor' on our planet*?" (1972). Jantsch attributes the degradation of these integrated systems to the linear, mechanistic, value-free thinking and action within our institutions, science and learning, and recognised that these ways of thinking and acting are expressions of the values that guide us (1970, 1972). For example, he invites the reader to consider the differences between "*adopting a notion of 'progress' (as inherent in Christian thought)*" as a value to purposively guide our thoughts and actions, and *"ecological balance", or a notion of cyclical development (as inherent in Hinduism and Buddhism)"* (Jantsch 1972).

Jantsch goes on to explore these insights in much greater detail in *The self-organising universe* (1980). Throughout this philosophical treatise, Jantsch systematically outlines the embryonic stages of the West's transition from a mechanistic, dualistic paradigm to a process-oriented, self-organising paradigm (concepts built upon and reformulated by Fritjof Capra (Capra 1996, p. 111)). Foreshadowing Nicolescu's three axioms of transdisciplinarity, Jantsch describes, according to this new process-focused paradigm: (1) the existence of multiple levels of reality, (2) their radical interconnectedness, and (3) the resulting notion of complementarity:

> In a **multi-level, evolving reality**, **opposites vanish ultimately**. There is no "good" and "evil"…Process thinking does not know any sharp separation between opposite aspects of reality. It also transcends a dialectic synthesis of opposites, that clumsy Western attempt at making a rigid structure of notions move and overcome its dualism. In process thinking,

> there is only complementarity in which opposites include each other. Friedrich Holderlin, in his Sophocles distich, has perhaps given this thought the most profound expression: Many seek vainly, joyously to express joy. Finally I apprehend it, here in my sorrow (273–274).

4.2.3 Moving to Nicolescu and Max-Neef

Nearly 20 years later, Basarab Nicolescu axiomatically codifies similar arguments in his *Manifesto of transdisciplinary*: the **ontological axiom** of multiple levels of reality (micro, macro, cosmo, or social, technical, cultural, etc.); the **epistemological axiom** of complexity (that these levels of reality are all radically interconnected and interdependent upon one another); the **logical axiom** of the included middle (which acknowledges the validity in seemingly contradictory truths, and that it is their existence that points to a different level of reality, where their unity is explained) (2002). Divergent to Jantsch, Nicolescu believes it is not necessary to explicitly articulate an axiological or values axiom because *"the combined action of the ontological, logical, and epistemological axioms engenders values"* (Nicolescu 2014). Nicolescu does not discuss this claim any further.

In 2005, Max-Neef brings together the theories of both Jantsch and Nicolescu in order to demonstrate weak and strong transdisciplinarity, respectively. After presenting Jantsch's (1970, 1972) integrated transdisciplinary systems approach to learning (presumably, as Max-Neef did not reference Jantsch), Max-Neef refers to this model as weak transdisciplinarity in that it is practically-minded and does not go "*deep into realms of reality"* (Max-Neef 2005). Nicolescu agrees that Jantsch "*falls into the trap of defining transdisciplinarity as a hyperdiscipline*" (2006, 2010). Instead, Max-Neef describes strong transdiscplinarity in terms of Nicolescu's three axioms, in which strong transdisciplinarity represents "*a clear challenge to the binary and lineal logic of Aristotelian tradition*".

Instead of relegating Jantsch's contributions entirely to 'weak' transdisciplinarity, we see complementarity between Jantsch's vision and Max-Neef's definitions of strong transciplinarity. Firstly, Jantsch, Max-Neef, and Nicolescu all criticise the reductive, binary, and linear logic of rational science and its role in creating the 'problematiques' of today (Jantsch 1980; Nicolescu 2002; Max-Neef 2005). Secondly, whereas Jantsch chooses to highlight our axiologies as a lever for transformation, and Nicolescu and Max-Neef prioritise an ontological and epistemological shift for transformation, we view all three meaning systems as strongly integrative, and think of them collectively as the three primary meaning systems of our worldviews (Hedlund-de Witt et al. 2014). Hence, combining the visions of Jantsch, Nicolescu and Max-Neef lengthens the *paradigmatic lever* (Meadows 1999) for change available to us. Our view is that this extended lever is still insufficient to generate the grand scale of transformation necessary in the Anthropocene. Before we expand on this, we first explore existing scholarship and the application of strong transdisciplinarity.

4.2.4 *Recent Applications of the Concept of Strong Transdisciplinarity*

Perhaps surprisingly, the application, critique and evolution of the term strong transdisciplinarity has been limited. In the main, authors incorporate an allegiance to strong transdisciplinarity in their definitions or introductions, but do not significantly critique or extend the term (Bagnol et al. 2016; Jacobs and Nienaber 2011; Khoo 2017; Kingsley et al. 2015; Putriene 2014). Either the term is used without acknowledging the fundamental characteristic of strong transdisciplinarity: the need for onto-epistemological shifts (Mastrangelo et al. 2015; Morton et al. 2015), or it is briefly interpreted as referring to the transcendence of positivism (Stock and Burton 2011). Balsiger (2015) argues that the strong/weak distinction is one of only a few conceptual frameworks of transdisciplinarity varieties, but does not incorporate strong transdisciplinarity into his proposed conception of *soft* and *hard* transdisciplinarity (representing levels of integration and collaboration). Aeberhard and Rist (2009) draw parallels between the diverse worldviews and paradigms within their agroecology project and the axiom of different levels of reality, while others briefly link the notion of strong transdisciplinarity to transcending isolating, reductionist, linear worldviews to more complex, interrelated, circular worldviews (Schweizer-Ries and Perkins 2012; Ingebrigtsen and Jakobsen 2012). In comparison, a few authors have engaged in a more in-depth application (Cole 2007; Cochrane 2014) and theorising (Buchanan, 2016; Clarke, 2016) of strong transdisciplinarity. Most recently, Cole (2017) deftly applies the axioms of strong transdisciplinarity to articulate an indigenous transdisciplinarity. However, the more limited and partial use of this potent concept provides part of the impetus for this chapter.

In the following sections, we expand on the premise of strong transdisciplinarity by exploring (a) the Cartesian-Newtonian paradigm, (b) critiques on why we should stretch or transcend it, and (c) other diverse meaning systems. Our intention is to offer tools for prompting third order collective learning, or "learning that facilitates a fundamental recognition of paradigm and enables paradigmatic reconstruction" (Sterling 2010). This paradigmatic stretching, as shown in Fig. 4.1 and described in Sect. 4.4, could drive more effective collaborative transdisciplinary research—that is, *Transforming Transdisciplinarity* research. Below we elaborate on why this is the case.

4.3 Critical Reading of the Past: What Is the Cartesian-Newtonian Paradigm and How Does It Drive These Wicked Problems?

In this section, we: (a) analyse and synthesise the defining characteristics of the Cartesian-Newtonian paradigm, (b) examine its origins, and (c) discuss how it drives the wicked complexities we face in transdisciplinary collaborative work.

4.3.1 The Defining Characteristics of the Cartesian-Newtonian Paradigm

Any paradigm is characterised by its firmly embedded assumptions and beliefs. Table 4.2 presents a distillation of the Cartesian-Newtonian characteristics viewed through the founding theorists of transdisciplinarity, and associated theoretical orientations (systems/complexity thinking, Indigenous and Eastern perspectives, and critical experiential learning). To structure the analysis in a way that is in line with our intent to extend beyond epistemology, ontology and axiology, we have added anthropology and social vision meaning systems, in line with De Witt et al. (2016) structure of worldviews, and we have added cosmology to accommodate key elements from the founding theorists. Table 4.2 makes clear a consensus about the embedded beliefs within and across meaning systems, amongst these foundational thinkers.

The patterns in a paradigm are significant. Dualism and hierarchy emerge as patterns across all six meaning systems in the Cartesian-Newtonian paradigm. These 'deeper logical operators' (Morin 2001) signify weak transdisciplinarity (Max-Neef 2005). According to Morin (2001) and Meadows (1999) each paradigm is partial and contains rationalisation, and thus we can only transcend our deepest paradigms and worldviews if we can recognise their concepts and logical operators.

4.3.2 From Where Does the Cartesian-Newtonian Paradigm Originate?

The origins of the Cartesian-Newtonian paradigm have been attributed to the ancient Greeks, patriarchal religion, and the rise and triumph of science (Kauffman 2016; Lent 2017). The pre-Socratic philosopher Parmenides, but more commonly, Aristotle, are described as influencing the underlying paradigmatic concepts and operators (Osberg 2015). Parmenides' view of reality was of a "changeless plenum", where reality is completely based on substance and is static (Osberg 2015). Aristotle attempts to bring truth to inquiry, through his three laws of thought:

1. Identity (A is A: a statement cannot not remain the same and change its truth value).
2. Non-Contradiction (A and not A: no statement is both true and false).
3. Excluded Middle (either A or not A: every statement is either true or false).

These three laws form a significant part of our epistemology today (Max-Neef 2005; Nicolescu 2010), and contribute to the disjunctive logical operator within the Cartesian-Newtonian paradigm, embodied for example in dualist thinking (those familiar with Nicolescu's logical axiom of the included middle know it is in direct reference to Aristotle's three rules of thought). Descartes', Bacon's, and Newton's development of science, and their complete separation of the subject from the object further embed this dualist and reductionist way of being (Capra 1982; Morin 2001, 2008; Nicolescu 2002, 2010; Kauffman 2016).

4.3.3 How Does the Cartesian-Newtonian Paradigm Drive Wicked Problems?

Collectively, Aristotle, Descartes, Newton and others created many now deeply embedded habits for understanding reality[1]:

- Objective knowledge of exterior objects (over subjective knowledge, i.e. feelings)
- Quantifiable, measureable, verifiable data (over qualitative, subjective data)
- Reductionist focus on parts (over holism)
- Deterministic laws of cause and effect (over chance events that laws cannot predict)
- Certainty (over uncertainty)
- Universal knowledge (over local knowledge relevant to only specific settings)
- One correct view of, or right ways for, a situation (over multiple, relevant, views)
- Either/or thinking (over accepting and working with ambiguity and paradox).

As illustrated in Table 4.3, Max-Neef, Jantsch, Nicolescu, Rittel and Webber (and representatives from the other theoretical orientations linked to strong transdisciplinarity) argue that these habits have in turn both developed and continue to exacerbate the wicked complexity which is the focus of much collaborative transdisciplinary research and learning (Berstein 2015; Brown et al. 2010; CIRET 1997; Ison 2017; Jahn et al. 2012).

We recognise the problems of the simplification evident in Table 4.3. Synthesising the representative behaviours of the Cartesian-Newtonian paradigm isomorphically with the six meaning systems is partial. Strong interdependencies exists between the meaning systems. The meaning systems interact and influence society in infinite ways, leading to complex external manifestations. Hence, while we have tried to map ways of being, knowing, doing to the meaning system each connects with most strongly, we recognise that many of these behaviours manifest through the interaction of multiple meaning systems. This is why we argue that Jantsch's axiological definitions and Max-Neef's onto-epistemological definitions should be seen as complementary: there is value and necessity in viewing these meaning systems together because of their interdependencies within a social paradigm or individual worldview. This interdepedency is also why we argue for further extending the number of which meaning systems considered in Transforming Transdisciplinarity.

[1] An adaptation of Montuori in Morin (2008, xxxi).

Table 4.3 Vignettes from theorists who argue the Cartesian-Newtonian paradigm is a driver of wicked complexities

System (sources)	Vignettes of synthesised Cartesian-Newtonian discourse
Cosmology Capra (1982, p. 40), Blackburn (1971), and Alhadeff-Jones (2008)	As the universe is a giant machine, we can know everything there is to know about it through reductionism, i.e. we can understand phenomena by reducing them to their constituent parts. This 'paradigm of simplicity', grounded in classical physics, tackles complex problems by reducing them to simple issues which are then solved independently and successively. As a result of this conventional disciplinary, reductionist, and compartmentalized approach, we focus on the weak but tangible interventions in a situation. *Focusing on the wrong interventions means problems continue to grow and complexify.*
Ontology De Witt et al. (2016), Nicolescu (2014), Morin (2001, p. 82), Sunde (2008), Obeng-Odoom (2016), and Dewey (1910)	As our universe is an unchanging, predictable machine, its parts (material), are devoid of meaning and intrinsically without purpose, and the human rational mind is the top of the hierarchy, separate from our souls, bodies, nature, world, and universe. This dualism and hierarchy contribute to feelings and actions of superiority and domination, *leading to inequitable treatment of nature and our fellow humans.*
Epistemology Capra (1982, p. 45), Scholz and Marks (2001), Montuori (2013), Kleiber (2001), Obeng-Odoom (2016), Macedo (2006, p. 16), Nicolescu (2002, 2014), and Morin and Kern (1998)	One of the most profound impacts of the Cartesian-Newtonian paradigm is the fragmented structure of knowledge, with increasing specialization and atomization (literally a splitting up into the smallest possible parts). Such unchecked mitosis has led to compartmentalisation, and hyperspecialization with false dichotomies between disciplines. Because specialisation stifles and prevents dialogue across boundaries, it throws civilization as we know it into question. We struggle to connect our specialisation to the social, cultural or historical reality. In addition, the proliferation of disciplines and knowledges makes a global and planetary view impossible, which fosters "unconsciousness and irresponsibility" ultimately bearing death. *For example, "the barbarism of specialization," is linked both to human tragedies (such as Hiroshima, the Holocaust, slavery), and to profit at the expense of ecosystems.*
Axiology Macy (1991, p. 104), Jantsch (1970), Nicolescu (2002, 2014), Abson et al. (2017), Rittel and Webber (1973), and (Blackburn 1971)	The false distinction between ends and means in the dominant paradigm manifests as the prioritization of ends over means (economic growth over equity) or the prioritization of means over ends (e.g. science for its own sake rather than for societal good). Furthermore, without considerations of values, ethics, and morals within both the means and ends, we have a periscope view which sees only efficiency and efficacy, e.g. with no regard for effectiveness. *This brings forth unfortunate consequences, such as the unbalanced triumph of techno-sciences and mindsets unprepared to deal with wicked problems.*

(continued)

Table 4.3 (continued)

System (sources)	Vignettes of synthesised Cartesian-Newtonian discourse
Anthropology Stuckey (2010), Capra (1982, p. 23), Blackburn (1971), and Barrett et al. (2016)	The combination of the normalized disconnect between humans and nature, value-scarce rational modes of thinking, and hyperspecialization result in the ecological crises of the Anthropocene. We have cut ourselves off from our natural environment and have since forgotten how to commune and cooperate with the rich diversity of living organisms. We rationalize and exploit the natural environment as if it exists in separate parts. Because of a primarily objective consciousness, we do not recognize our guilt in this. *This binary (we see ourselves as separate) and authoritarian (we believe we can predict and control) relationship with nature ultimately catalysis climate change, mental illness and other socio-ecological disasters*.
Social vision Morin (2001), Meadows (2004), Capra (1982, p. 11), Espinosa and Walker (2017), Callon (2005), Kleiber (2001), Lange (2017, in press), Freire (1970/1996), and Abson et al. (2017)	Linear, reductionist, hierarchical thinking also provides the foundations for "economy first" and the myth of guaranteed progress and unlimited growth in our economy, which is the fundamental ailment of Western society. *This enables and hides dehumanization, across the globe, with irreversible and complex impacts on the environment.*

Note that the entries in the table are a synthesis of the sources and therefore draw directly on their discourse and emotive language.

4.4 Forging New Meaning Systems

In the previous section, we outlined the Cartesian-Newtonian paradigm, which according to Jantsch, Max-Neef and Nicolescu, and many other key transdisciplinary theorists, is at odds with Transforming Transdisciplinarity. In this section, we illustrate meaning systems (mythic structures) that seek to balance or stretch the dominant Cartesian-Newtonian ways of being, knowing, and doing towards Transforming Transdisciplinarity (Table 4.4). The summaries below are indicative vignettes of inspiration from thinkers whose complexivist paradigms align with the ways of being required for third order (deeply effective) collaboration and collective learning.

One of the defining features in Table 4.4's synthesis is the repeated reiteration of a new logic of reality, of non-duality, relation and interconnection. Similar in character to Bohr's eternalised motto "*Contraria Sunt Complementa*" (opposites are complementary) (Max-Neef 2005), they are all variations on a theme: Nicolescu's Logic of the Included Middle (2002, 2014); Freire's dialectics (1970; Darder 2015); Capra's re-balancing of the paradigmatic yin and yang (1982); and Dewey's cyclical homeostasis and philosophy of experience (1910, 1938; Garrison et al. 2012). Again, the language in Table 4.4 is directly representative of the sources.

Table 4.4 Examples of visions for alternative mythic structures: paradigmatic stretching and/or restructuring

System	Vignettes for paradigmatic restructuring or stretching
Cosmology Jantsch (1980), Kauffman (2016), and Aluli Meyer (2013)	The universe as a self-organising, creative and co-creating realm in which the possibilities for further evolution and increasing complexity, as a result of its continual change, are so infinite that it is impossible to predict the future. And/or the universe is alive and it is a realm within which all things are related (e.g. relatives).
Ontology Nicolescu (2002, 2014), Barrett et al. (2016), Darder (2015), Dewey (1910), Morin (2006), Barad (2007), and Capra (1982)	In nature there are different levels of natural and social reality and correspondingly, different levels of perception; for example, microphysical, macro-physical, cyberspacetime, or individual, geographical, historical, planetary. These levels of reality are universally interdependent. Everything is radically interconnected, meaning that any analysis of local causality can only ever be an extremely partial view. Even though the levels of reality might seem contradictory or opposite, they are actually related in a broader whole and they are complementary. For example, diverging, contradictory realities are valid and they are needed to explain reality. Nature (i.e. more-than-human) can be conscious and has an ability to communicate with humans and vice versa. Perhaps true reality is inexpressible. The observer, just by looking, changes reality.
Epistemology Barrett et al. (2016), Freire (1974/2005), Darder (2015), Dewey (1933), Nicolescu (2002, 2014), Aluli Meyer (2013), Morin (2001), and Stuckey (2010)	Knowledge is temporal, historical, relational, emotive, refutable, perspectival, inseparable from the knower, ephemeral, partial, collatable and integratable, loving, more-than-human, flawed, easily rationalized. Transrational-intuitional and embodied knowing is valid and valuable.
Axiology Nicolescu (2002), Macy (1991), and Freire (1970/1996)	The subject and the object, researchers and the researched, are re-integrated, e.g. values and subjectivity are explicitly recognised within inquiry.
Anthropology Sunde (2008) and Morin (2001)	Humans explore trans-anthropocentric, trans-simplistic relationships with nature, in which nature, with equal rights and consciousness, is valued, and deep interconnectedness is recognised.
Social vision Raworth (2017) and Freire (1970/1996)	A vision in which liberation, hope, and equity are prioritised over economic and government ideologies.

4.5 The Role of Transforming Transdisciplinarity

Based on the above discussion, we propose the concept of Transforming Transdisciplinarity. This concept implies a type of transdisciplinarity that not only includes the axiological, ontological and epistemological stretching implied by Jantsch, Nicolescu and Max-Neef, but has a strong transformative, third order learning intent, in which the entirety of the meaning systems of our paradigms and worldviews are stretched.

Every transdisciplinary and collaborative research experience can help stretch, broaden, and rebalance the Cartesian-Newtonian paradigm, through deeper and more critical reflection on and mindfulness of the assumptions and beliefs within which we operate and thus the outcomes we are manifesting. If we reflect on the characteristics of our mythic framework, as well as the logical structuring our framework, we avoid slipping into an unproblematized periscope focus on the present and on "how" to do collaboration. In other words, how can we enable a deeper, more critical reflection on the "why" and "so what" or mythic grounds that support us, and on the conclusions towards which they tend (Dewey 1933; Kauffman 2016)?

Third order learning (i.e. paradigmatic reconstructive learning) is challenging. Paradigms and worldviews deeply influence our behaviour (De la Sienra et al. 2017), and are buried deep within our consciousness, and they generally go unquestioned and unstated (Lent 2017). As societies and cultures evolve over long periods, rules and norms are carried along (Dewey 1933/1998; Mezirow 1994), preserved by way of historical commonsense (Gramsci 1971), a sort of cultural transmission. An individual's sub-conscious absorbs and embodies these deep histories and paradigms, which then sit within the realm of unexamined assumptions, or "anti-dialectical assumptions", because we are not willing to entertain the possibility that their "opposites" may in fact have validity (Darder 2015, p. 20). Thus, paradigms "*make us unconscious*" (Morin 2001, p. 25). These externally imposed rules for processing (or not processing) the world within which we exist are so powerful that they tend to trap us in the state of being Objects of history (i.e. being under the control of), as opposed to being liberated into a more fully human experience in which we become Subjects of history (i.e. exerting influence on) (Freire 1974/2005; Kolb 2015). This cultural transmission influences an individual's ways of being, doing and knowing, and can be conceived of as both a natural process of societal living, and an intentional form of inculcation by hegemonic powers to maintain the status quo (Macedo 2006; Freire 1970/1996). For collaborative research to contribute to address the challenges of the Anthropocene, it needs to enable and embed paradigmatic learning within it, in order to operate in a Balancing feedback loop (Fig. 4.1). Here, we offer some starting points to scaffold the translation of Transforming Transdisciplinarity into practice.

Third order learning requires reflexivity: "finding strategies to question our own attitudes, thought processes, values, assumptions, prejudices and habitual actions, to strive to understand our complex roles in relation to others, [… to] becom[e] aware of the limits of our knowledge, of how our own behaviour plays into […] practices" (Bolton 2010, pp. 14–15). In other words, reflexivity encompasses critical reflection on the mythic structures that direct our ways of knowing, being, and doing. The holism inferred in our re-interpretation of strong transdisciplinarity across cosmology, epistemology, ontology, axiology, anthropology, and social vision provides a means to practice reflexivity via its diverse array of entry points. The process and complexivist orientations outlined in Table 4.4 provide a starting point for exploring how else things might be.

The practical process of planning and conducting a collaborative transdisciplinary project also provides multiple entry points for reflexive practice. Structured exploration at the beginning of transdisciplinary projects can begin with deceptively simple questions, such as *How did we get here, to these wicked problems*? and *Where do we want to go*? Reflexivity requires being mindful of the languages of a collaborative research group. A Transforming Transdisciplinary approach might seek to examine the literature the group is reading: What is its underlying logic? Are things represented hierarchically, simplistically or dualistically? A group looking to strengthen its third order learning could engage with, and group dialogue around, some of the authors in Table 4.4. What do individuals notice about their own responses to these and other mythic structures? Beyond these simple questions, there are many approaches from constituent fields that provide different ways to map the territory, such as:

- Soft systems methodology and its notion of purpose (Checkland and Poulter 2010)
- System thinking and its notion of intervention points (Meadows 1999)
- Causal layered analysis and its notion of myths and metaphors (Inayatullah 2008)
- The Cynefin model and its notion of complexity (Snowden and Boone 2007)
- Meta-governance and its notions of values (Kooiman and Jentoft 2009).

4.6 Conclusion

Transforming Transdisciplinarity and its concomitant commitment to deep collaborative learning holds great potential as a lever that can help to generate the scale of transformation required to meet the challenges of the Anthropocene. Re-interpreting strong transdisciplinarity as encompassing a broader set of elements of a paradigm or a worldview (cosmology, ontology, epistemology, axiology, anthropology, and social vision) extends the potential of the lever. However, developing the capacity to enact Transforming Transdisciplinarity in practice requires a rare level of reflexivity that in itself challenges the fundamental structures of much of the academy and society. Creating spaces to build our collective capacity to practice Transforming Transdisciplinarity is therefore essential.

References

Abson, D., Fischer, J., Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., et al. (2017). Leverage points for sustainability transformation. *Ambio, 46*, 30–39.

Aeberhard, A., & Rist, S. (2009). Transdisciplinary co-production of knowledge in the development of organic agriculture in Switzerland. *Ecological Economics, 68*, 1171–1181.

Alhadeff-Jones, M. (2008). Three generations of complexity theories: Nuances and ambiquities. *Educational Philosophy and Theory, 40*(1), 66–82.

Aluli Meyer, M. (2013). Holographic epistemology: Native common sense. *China Media Research, 9*(2), 94–101.

Bagnol, B., Clarke, E., Li, M., Maulaga, W., Lumbwe, H., McConchie, R., et al. (2016). Transdisciplinary project communication and knowledge sharing experiences in Tanzania and Zambia through a One Health Lens. *Frontiers in Public Health, 4*(10), 1–6.

Balsiger, J. (2015). Transdisciplinarity in the class room? Simulating the co-production of sustainability knowledge. *Futures, 65*, 185–194.

Barad, K. (2007). *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning*. Durham/London: Duke University Press.

Barrett, M. J., Harmin, M., Maracle, B., Patterson, M., Thomson, C., Flowers, M., & Bors, K. (2016). Shifting relations with the more-than-human: Six threshold concepts for transformative sustainability learning. *Environmental Education Research, 23*(1), 131–143.

Berstein, J. H. (2015). Transdisciplinarity: A review of its origins, development, and current issues. *Journal of Research Practice, 11*(1), Article R1.

Blackburn, T. (1971). Sensuous-intellectual complementarity in science. *Science, 172*(3987), 1003–1007.

Bolton, G. (2010). Reflection and reflexivity: What and why. In G. Bolton (Ed.), *Reflective practice: Writing and professional development*. London: Sage.

Brown, V. A., Harris, J., & Russel, J. (2010). *Tackling wicked problems through the transdisciplinary imagination*. New York: Earthscan.

Buchanan, J. (2016). *Developing a transdisciplinary heuristic framework for complex problems in agriculture and environment*. Madison: University of Wisconsin.

Callon, M. (2005). Disabled persons of all countries, unite! In B. Latour & P. Weibel (Eds.), *Making things public: Atmospheres of democracy*. Cambridge, MA: MIT Press.

Capra, F. (1982). *The turning point: Science, society and the rising culture*. New York: Harper Collins.

Capra, F. (1996). *Web of life*. London: Harper Collins.

Checkland, P., & Poulter, J. (2010). Soft systems methodology. In M. Reynolds & S. Holwell (Eds.), *Systems approaches to managing change: A practical guide* (pp. 191–242). London: Springer.

CIRET. (1997). *Declaration and recommendations of the international congress: Which University for Tomorrow? Towards a transdisciplinary evolution of the university*. Locarno Declaration. Locarno, Switzerland.

Clarke, E. A. (2016). *The synergies of difference: Strengthening transdisciplinary research practice through a relational methodology*. Canberra: Australian National University.

Cochrane, J. R. (2014). Thinking about complexity: Transdisciplinarity and research on religion and health in Africa. *Religion and Theology, 21*, 333–357.

Cole, A. (2007). Mediated modelling, strong transdisciplinarity and sustainable resource management in the Motueka Catchment of New Zealand. *International Journal of Sustainable Development, 10*(4), 345–364.

Cole, A. (2017). Towards an indigenous transdisciplinarity. In H. Dieleman, B. Nicolescu, & A. Ertas (Eds.), *Transdisciplinarity & interdisciplinarity: Education and research* (pp. 129–160). The Academy of Transdisciplinary Learning & Advanced Studies Publishing. Geneva: Inderscience Publishers

Darder, A. (2015). *Freire and education*. New York: Routledge.

De la Sienra, E., Smith, T., & Mitchell, C. (2017). Worldviews, a mental construct hiding the potential of human behaviour: A new learning framework to guide education for sustainable development. *Journal of Sustainability Education, 13*(March), 1–21.

De Witt, A., de Boer, J., Hedlund, N., & Osseweijer, P. (2016). A new tool to map the major worldviews in the Netherlands and USA, and explore how they relate to climate change. *Environmental Science and Policy, 63*, 101–112. https://doi.org/10.1016/j.envsci.2016.05.012.

Dewey, J. (1910). *The influence of Darwin on philosophy and other essays in contemporary thought*. New York: Henry Holt and Company.

Dewey, J. (1933/1998). *How we think: A restatement of the relation of reflective thinking to the educative process*. Boston: Houghton Mifflin.
Dewey, J. (1938/1963). *Experience and education*. New York: Collier.
Espinosa, A., & Walker, J. (2017). *A complexity approach to sustainability: Theory and application* (2nd ed.). London: Impreiral College Press.
Freire, P. (1970/1996). *Pedagogy of the oppressed*. London: Penguin.
Freire, P. (1974/2005). *Education for critical consciousness*. London: Continuum.
Garrison, J., Neubert, S., & Reich, K. (2012). *John Dewey's philosophy of education: An introduction and recontextualization for our times*. New York: Palgrave MacMillan.
Gramsci, A. (1971). *Selections from the prison notebooks of Antonio Gramsci*. London: Lawrence & Wishart.
Hedlund-de Witt, A., de Boer, J., & Boersema, J. J. (2014). Exploring inner and outer worlds: A quantitative study of worldviews, environmental attitudes, and sustainable lifestyles. *Journal of Environmental Psychology, 37*, 40–54.
Inayatullah, S. (2008). Six pillars: Futures thinking for transforming. *Foresight, 10*(1), 4–21.
Ingebrigtsen, S., & Jakobsen, O. (2012). Utopias and realism in ecological economics – Knowledge, understanding and improvisation. *Ecological Economics, 84*, 84–90.
Ison, R. (2017). Transdisciplinarity as transformation: A cybersytemic thinking in practice. In D. Fam, J. Palmer, C. Reidy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability outcomes*. London: Routledge.
Jacobs, I., & Nienaber, S. (2011). Waters without borders: Transboundary water governance and the role of the 'transdisciplinary individual' in Southern Africa. *Water South Africa, 37*(5), 365–378.
Jahn, T., Bergman, M., & Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics, 79*, 1–10.
Jantsch, E. (1970). Inter- and transdisciplinary university: A systems approach to education and innovation. *Policy Sciences, 1*, 403–428.
Jantsch, E. (1972). Towards interdisciplinarity and transdisciplinarity in education and innovation. In L. Apostell, G. Berger, A. Briggs, & G. Michaud (Eds.), *Interdisciplinarity: Problems of teaching and research in universities* (pp. 97–127). Paris: Centre for Educational Research and Innovation and OECD.
Jantsch, E. (1980). *The self-organising universe: Scientific and human implications of the emerging paradigm of evolution*. Oxford: Pergamon Press.
Kauffman, S. (2016). *Humanity in a creative universe*. New York: Oxford University Press.
Khoo, S.-M. (2017). Sustainable knowledge transformation in and through higher education: A case for transdisciplinary leadership. *International Journal of Development Education and Global Learning, 8*(3), 5–24.
Kingsley, J., Patrick, R., Horwitz, P., Parkes, M., Jenkins, A., Massy, C., et al. (2015). Exploring ecosystems and health by shifting to a regional focus: Perspectives from the Oceania EcoHealth chapter. *International Journal of Environmental Research and Public Health, 12*, 12706–12722.
Kleiber, C. (2001). What kind of science does our world need today and tomorrow? A new contract between science and society. In J. Thompson Klein et al. (Eds.), *Transdisciplinarity: Joint problem solving among science, technology, and society. An effective way for managing complexity* (pp. 47–58). Boston: Birkhauser Verlag.
Kolb, D. (2015). *Experiential learning: Experience as the source of learning and development*. Upper Saddle River: Pearson Education.
Kooiman, J., & Jentoft, S. (2009). Meta-governance: Values, norms, and principles, and the making of hard choices. *Public Administration, 87*(4), 818–836.
Kuhn, T. (1996). *The structure of scientific revolutions*. Chicago: University of Chicago Press.
Lange, E. (2017). Transformative sustainability education: From sustainababble to a civilization leap. In M. Milana, S. Webb, J. Holford, R. Waller, & P. Jarvis (Eds.), *Palgrave international handbook on adult and lifelong education and learning*. Basingstoke: Palgrave Macmillan (in press).

Lent, J. (2017). Introduction: Shaping our history. In J. Lent (Ed.), *Patterning instinct: A cultural history of humanities search for meaning*. New York: Promethus Books.

Lewis, S., & Malsin, M. (2015). Defining the Anthropocene. *Nature, 519*, 171–180.

Macedo, D. (2006). *Literacies of power: What Americans are not allowed to know*. Cambridge, MA: Westview Press.

Macy, J. (1991). *World as lover; world as self*. Berkeley: Parallax Press.

Mastrangelo, M., Weyland, F., Herrera, L. P., Villarino, S., Barral, M., & Auer, A. D. (2015). Ecosystem services research in contrasting socio-ecological contexts of Argentina: Critical assessment and future directions. *Ecosystem Services, 16*, 63–73.

Max-Neef, M. (2005). Foundations of transdisciplinarity. *Ecological Economics, 53*(2005), 5–16.

Meadows, D. (1999). *Leverage points: Places to intervene in a system*. The Sustainability Institute: Vermont.

Meadows, D. (2004). *The limits to growth: The 30-year update*. White River Junction: Chelsea Green Publishing Company.

Mezirow, J. (1994). Understanding transformation theory. *Adult Education Quarterly, 44*(4), 222–232.

Montuori, A. (2013). Complexity and transdisciplinarity: Reflections on theory and practice. *World Futures, 69*(4-6), 200–230.

Montuori, A. (2017). Nature of creativity. In E. G. Carayannis (Ed.), *Encyclopedia of creativity, invention, innovation and entrepreneurship*. New York: Springer.

Morin, E., & Kern, A. B. (1998). *Homeland earth: A manifesto for the new millenium*. Cresskill: Hampton Press.

Morin, E. (2001). *Seven complex lessons in education for the future. Education on the move*. Paris: UNESCO Publishing.

Morin, E. (2006). *Restricted complexity, general complexity*. Presented at the Colloquium "Intelligence de la complexit́ e :́ epist́ emologie et pragmatique". Cerisy-La-Salle, France.

Morin, E. (2008). *On complexity*. New Jersey: Hampton Press.

Morton, L. W., Eigenbrode, S. D., & Martin, T. A. (2015). Architectures of adaptive integration in large collaborative projects. *Ecology and Society, 20*(4), 5.

Nicolescu, B. (2002). *Manifesto of transdisciplinarity* (K. C. Voss, Trans.). New York: State University of New York Press.

Nicolescu, B. (2006). Transdisciplinarity – Past, present, future. In B. Haverkort & C. Reijntjes (Eds.), *Moving worldviews – Reshaping sciences, policies and practices for endogenous sustainable development* (pp. 142–166). Leusden: Compas Editions.

Nicolescu, B. (2010). Methodology of transdisciplinarity – Levels of reality, logic of the included middle and complexity. *Transdisciplinary Journal of Engineering & Science, 1*(1), 19–38.

Nicolescu, B. (2014). Methodology of transdisciplinarity. *World Futures, 70*(3–4), 186–199.

Obeng-Odoom, F. (2016). Editorial: The wretched of the earth. *Journal of Australian Political Economy, 78*, 5–23.

Osberg, D. (2015). Learning, complexity and emergent (irreversible) change. In D. Scott & E. Hargreaves (Eds.), *The Sage handbook of learning* (pp. 23–50). Los Angeles: Sage.

Putriene, N. (2014). Interdisciplinary study programs: Controversies of concept and structure. *Social Sciences, 4*(86), 70–77.

Raworth, K. (2017). *Doughnut economics: Seven ways to think like a 21st-century economist*. London: Cornerstone Publishing.

Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*, 155–169.

Rockström, J., Steffen, W., Noone, K., Persson, A. s., Chapin, F. S. I., Lambin, E., et al. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society, 14*(2), 32.

Scholz, R., & Marks, D. (2001). Learning about transdisciplinarity: Where are we? Where have we been? Where should we go? In J. Thompson Klein, W. Grossenbacher-Mansuy, R. Häberli, A. Bill, R. W. Scholz, & M. Welti (Eds.), *Transdisciplinarity: Joint problem solving among sci-*

ence, technology and society. An effective way for managing complexity (pp. 236–252). Boston: Berkhauser-Verlag.

Scholz, R., & Steiner, G. (2015). The real type and ideal type of transdisciplinary processes: Part I – Theoretical foundations. *Sustainability Science, 10*(4), 527–544.

Schweizer-Ries, P., & Perkins, D. D. (2012). Sustainability science: Transdisciplinarity, transepistemology, and action research: Introduction to the special issue. *Umweltpsychologie, 16*(1), 6–11.

Snowden, D., & Boone, M. (2007). A leader's framework for decision making. *Havard Business Review, 85*(11), 69–76.

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015). The trajectory of the Anthropocene: The great acceleration. *The Anthropocene Review, 2*(1), 81–98.

Sterling, S. (2010). Transformational learning and sustainability: Sketching the conceptual ground. *Learning and Teaching in Higher Education, 5*, 17–33.

Stock, P., & Burton, R. J. F. (2011). Defining terms for integrated (multi-inter-trans-disciplinary) sustainability research. *Sustainability, 3*, 1090–1113.

Stuckey, P. (2010). Being known by a birch tree: Animist refigurings of western epistemology. *Journal for the Study of Religion, Nature and Culture, 4*(3), 182–205.

Sunde, C. H. (2008). The water or the waves: Toward an ecosystem approach for cross-cultural dialogue on the Whanganui River, New Zealand. In D. Waltner-Toews, J. J. Kay, & N.-M. E. Lister (Eds.), *The ecosystem approach: Complexity, uncertainty and managing for sustainability*. New York: Columbia University Press.

Chapter 5
The Role of *Pliability* and *Transversality* Within Trans/Disciplinarity: Opening University Research and Learning to Planetary Health

Jason Prior, Carole M. Cusack, and Anthony Capon

5.1 Relationality

Whilst many assert that disciplinarity is in crisis, disciplinarity continues to define the contemporary university: disciplines composed of departments of knowledge, subjects, and methods, each with its own concept of research and learning, have become the basic structures of the modern university; they extend beyond the walls of the university to academic journals and professionalism, which have come to regulate academic and professional employment; and beyond that they extend into the very materiality of the world. In theory, people can rely on health, like other disciplines, to be *consistent*. At the same time, there is a growing consensus that disciplines are anything but *consistent* (Appadurai 1996; Kelley 1997; Valenza 2009). Foucault, amongst others, has taught us the importance of looking to the genealogy of disciplines, highlighting their discontinuities, temporalities, conflicts, and shifting territorialities (Foucault 1973, 1979, 1991).

Disciplinarity has been subjected to many qualifying prefixes: inter-, multi-, trans-, pluri-, de-, anti-, in-, meta- and post-, and trans-. *Trans*disciplinarity, a focus of this chapter, is one of the qualifying prefixes to which disciplinarity has been subjected in the course of the last century. Transdisciplinarity is something different from multidisciplinarity or interdisciplinarity (Cilliers and Nicolescu 2012; Nicolescu 2002), and it is not a new discipline or a new superdiscipline, or postdisciplinarity

J. Prior (✉)
University of Technology Sydney, Institute for Sustainable Futures, Sydney, NSW, Australia
e-mail: jason.prior@uts.edu.au

C. M. Cusack
Department of Studies in Religion, The University of Sydney, Sydney, NSW, Australia

A. Capon
University of Technology Sydney, Institute for Sustainable Futures, Sydney, NSW, Australia

Sydney Medical School, The University of Sydney, Sydney, NSW, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_5

(Messer-Davidow et al. 1993, pp. 397–461). Over the past 50 years, whether it be law, religion (Loubser 2015), health (Whitmee et al. 2015), or planning (Després et al. 2011; Rizzo and Galanakis 2015; Smith and Jenkins 2015), various disciplines have sought to invoke transdisciplinary research. Arguably, these calls for transdisciplinarity from within disciplines are: a response to the emergence of the hyper-specialization of research and learning within the context of disciplines; a chance to promote the openness of research and learning; and the democratisation of research to enable opportunities for research and learning to become an ability and facility of more than disciplines and disciplinarians. As Guattari et al. assert:

> *The [UN] Charter of Human Rights ought to include an article on the right of everyone to research*. All social groups, all professions, minorities … have a need of the research [and learning] that concerns or implicates them. Creating a pole for the singularization, the particularization of research, balancing out the pole of the universal rationality of science seems indispensable. It is a matter here of the affirmation of a new paradigm of processual creation, linked to aesthetics in the social domain. (2015, p. 132)

The value, or axiological target, of this opening up of research and learning, is to cease focusing on the "Truth with a capital T" found in the research and learning of disciplinarians, and invoke research and learning "instead … in a social body whose destiny is in question … [and to enlarge]… the horizons of research" (Guattari et al. 2015). To take this research and learning path is not to imply an abandonment of disciplinarity for transdisciplinarity. This point is reinforced by other scholars such as Nicolescu, who have highlighted that transdisciplinarity and disciplinarity are intimately connected: "Transdisciplinarity is nourished by disciplinarity; in turn, disciplinarity is clarified by transdisciplinary knowledge in a new and fertile way" (Nicolescu 2002, 44–45). To highlight this intimate connection, it is often argued that transdisciplinarity within the university research and learning context should not replace disciplinarity but supplement it (see both Nicolescu (2002) and Fam et al. 2018, Chap. 7 in this book).

This chapter focuses on this intimate connection between transdisciplinarity and disciplinarity by exploring their relationality, and how components of this relationality promote the potential for openness in university research and learning. We identify two components of this relationality: *pliability and transversality*. This chapter argues that disciplines, be they science, planning, law, health or religion, manage to be both open to change, constantly becoming-other, and universal, abstract, and eternal. Whilst this *pliability* of disciplinarity is often translated as disciplinary inadequacy, we argue that it is a valuable component of disciplinarity, and that it provides a site for the *transversality* of transdisciplinarity which further promotes the potential opening of university research and learning.

Whilst this paper is primarily a conceptualisation of the relationality between disciplinarity and transdisciplinarity, we demonstrate and discuss this through reference to a recent *problematization* of disciplinary research at the human and environment nexus, which has given rise to the holistic notion of planetary health (Capon 2017; Horton et al. 2014; Whitmee et al. 2015) and its explicit call for substantial and urgent expansion of transdisciplinary research activities and the capacity to promote that expansion (Horton 2016; Whitmee et al. 2015). We begin with *pliabil-*

ity; we then discuss *transversality*, and conclude with an overview of their relationality and their contributions to the openness of university research and learning.

5.2 Pliability

Disciplines, be they health, law, religion, or planning, are often idealized as abstract, rational and reasoned, and as involving norms, rules and beliefs which are used to develop principled ways of formulating and resolving questions about the world we live in. For example, as Latour notes in his ethnography of the Conseil D'Etat (Latour 2010), this conception of law as a discipline is carried through to the practices of law-making itself, which, in its idealized form, happens in purified, learned spaces where there is opportunity for individuals to apply high-level reasoning free from contamination or distraction. In effect law, like other disciplines, is often idealized as *clean*. Moreover, disciplines are often idealized as eternal, or at least temporally consistent, and as not changing from one day to another without disciplinary justification (Luhmann et al. 2008).

Yet the world is far from *clean*: its inherent complexity means that disciplines worked through in the abstract do not seem so clear-cut when one is dealing with actual situations in the world. So, disciplines adapt. They indulge in inconsistencies, contradictions, even paradoxes (Hawkins 1984). However, they cover them up in their own peculiarly disciplinary ways. Disciplines are the perfect dissimulators: they manage to be both open to change, pliable, constantly becoming-other *and* universal, abstract, eternal. Whilst disciplines may often appear abstract, free from the constraints of place, matter and bodies, at the same time, whether they be planning, law, health or religion they have always, necessarily been material, spatial, corporeal, and contingent. How else could they apply themselves? But here is the crux of the matter: disciplines are always double, with their two sides folded into each other, a pliable construction of varying expectations. Here, we understand disciplinary *pliability* as that aspect of a discipline that enables it to remain both flexible and unchanging, and through which these two sides enter into a *fold* (in French *pli*, hence *pli*able) with each other (Deleuze 2006).[1] The fold of disciplinary abstraction and disciplinary concreteness creates an order that ebbs and flows, adapting to the world while allowing the world to adapt to this ever-changing order (Deleuze and Guattari 1987). Drawing from other research, we can understand this fold of disciplinary abstraction and disciplinary concreteness as disciplinary-scapes; in this sense we loosely draw on established terms like *lawscape* (Philippopoulos-Mihalopoulos 2012, 2013), but argue that there are as many scapes as disciplines, for example *architecturescape, planningscape* and *healthscape*.

[1] See Deleuze (2006), where the fold ("le pli"), rather than the point or the line, is the main unit of *becoming*. The fold encapsulates difference in unity, but a fragmented unity that keeps on becoming, indeed folding and unfolding. This is also our idea of pliability, as the flexibility of adaptation yet the consistency of constancy.

This pliability is often seen as disciplinary inadequacy, or disciplinary weakness. Clearly planning, health, law and other disciplines are there to marginalise uncertainty, but when confronted with the uncertainty of the world they often appear wanting: it would seem that they cannot adequately deal with the multiplicity of the world. Disciplines in action can appear distinctly muddy and far from clean.

We argue that this double, folded, pliable nature of disciplines is not only a generic but a defining feature of disciplinarity. We suggest that this disciplinary pliability is to be embraced as a means of ensuring the openness of research and learning. This pliability emphatically does not mean flexibility in the traditional sense of discretion and adaptability: it includes but is not limited to them. Pliability is the folding together of the universal abstraction and the concrete application of disciplines. Often, the abstraction and concreteness of disciplines co-exist unseen, in harmony. At other times, they may become discordant, a site of becoming other, a means for ensuring the openness of research and learning. An example of this discordance, and becoming-other, can be seen in the recent emergence of the discipline of planetary health. Planetary health problematizes existing health disciplines by disrupting the seamlessness of the health discipline's double folded nature.

First, planetary health, it is argued, stands for a broader approach to health than that usually adopted within existing health departments and their structures of knowledge, subjects, methods, or concepts of research. The planetary approach to health asks us to think beyond personal or societal approaches to health. It asks us to think beyond public health and global health, and beyond even a judicious combination of the two in ecological public health. It asks us to think of the health of civilisations and the planet. Planetary health asks us to think further, beyond personal or societal approaches to health, including public health and global health, or even their judicious combination in ecological public health (Lang and Rayner 2012; McLaren and Hawe 2005; McLeroy et al. 1988), to the health of civilisations and the planet (Haines et al. 2015; Horton 2015a, b, 2016; Horton and Lo 2015; Whitmee et al. 2015). We are asked to consider a new knowledge of 'health', one that is:

> not only concerned with *human health*, or even *animal health* [often referred to as one health]. Its subject is the oneness of all life and the symbiosis of life with our planet. Planetary health differs from global health in one other important respect. Planetary health is concerned with time. Looking back, it asks us to study past civilisations to understand how our species assembled into communities, thrived as societies, and struggled to sustain its future in the face of interior and exterior threats. Looking forward, its scope is not only the next year or even the next decade. Its range is at least the next 500 years, the track of time it takes for a civilisation to emerge and, quite possibly, collapse or decline. (Horton 2016)

Secondly, and at the same time, however, planetary health does not merely disrupt the abstract ordering of health disciplines. Instead, planetary health brings forth a transformed concreteness, a different spatial, temporal, material and embodied way of being in the world. We will use one example here from planetary health: the way in which it makes health 'other' through its acknowledgment of the planet earth as an important health subject. No longer are we asked to just consider the health of humans or animals as the focus of health discourse and practice; we are also asked to consider the health of the planet, and the symbiotic relationship between human health and the health of the planet (Clark 2015; Demaio and Rockström 2015). As Norton notes: "our actions must respond to the fragility of our planet and our obligation to safeguard the physical and human environments within which we exist" (Horton et al. 2014, p. 847).

The complex disciplinary origins of this emergence of the earth as a subject of health will be discussed more in the following section on transversality. Here, we just want to make broad reference to this new health subject and its spatiality, temporality, materiality and embodiment. The identification of the earth as the subject of planetary health required a conceptual 'unification' of the earth: the idea of an earth whose subsystems are tightly coupled, but which can be affected by its openness to cosmic and deep earth processes, as well as nudged into an alternative operating state by one of its sub-component species, such as humans. This unification of the earth into a subject is paradoxical. The paradox is that the very configuration of the earth into a single, integrated system has emerged due to the impacts of a more disintegrated, fractious and multiple vision of the planet (Clark 2015).

The emergence of the discipline of planetary health provides an example of the double, folded, pliable nature of the health disciplines, as sets of practices, discourses and forms of knowledge, that make sense of the world and operate within it. It highlights how the pliability of disciplines provides an opportunity for the becoming other of disciplines. Planetary health is an example of how the problematization of the discipline of health creates a constant oscillation between two points of view. According to one point of view, health in action is seen as an abstracting force which attempts to make clear-cut distinctions between different knowledges and objects. The other point of view acknowledges the realities of a world where people breathe and die, volcanoes explode, tectonic plates shift, ice melts, rivers meander, and social customs and norms change.

It is worth noting that in this type of problematization of disciplines, and in the pliability that results, the oscillation between shifting abstractions and concreteness creates a liveliness in the becoming of the discipline which opens up research and learning. As we have previously stated, this may be thought of as disciplinary inadequacy, and as arbitrary or inconsistent when judged against a narrow interpretation of what constitutes disciplinarity. This becoming through pliability does not guarantee shift or outcome, but provides an opportunity and trajectory. In many instances, it is tempting to denounce the pliability of disciplines as a failure to uphold certain disciplinary boundaries and principles, yet we do not wish to condemn disciplinary pliability on this basis. Instead, we choose to reflect on the way their inherent pliability is enacted in the presence of both abstract principles and the uncertainty, contingency and messiness of the world. This enactment of pliability promotes the openness of research and learning.

In this section it is worth remarking that medicine, whilst central to the modern discipline of health within the university, has arguably only recently begun to engage with the notion of planetary health. The notion of planetary health problematizes the dominant twentieth century biomedical model of health, which is currently the foundation of medicine, and originates from Virchow's conclusion that all disease results from cellular abnormalities (Porter 1997). This biomedical model of health is relevant for many diseases, it has intuitive appeal, and it is supported by a wealth of biological evidence (Wade and Halligan 2004). However, in many universities with medical faculties the discipline of medicine seemingly seeks to control the discourse of health, and to define it through this lens of biomedical understandings to the exclusion of other models of health. To respond effectively to the human health challenges of the Anthropocene epoch, it is essential that the discipline of medicine let go of some of the sovereignty of health discourse and opens itself up to other disciplinary perspectives. Planetary health challenges this contemporary health paradigm by arguing for an ecosocial approach to health (McMichael 1993) to complement the biomedical approach.

An ecosocial approach focuses on the ecological, economic and social foundations of health and necessitates the attention of other disciplines including environmental science, political economy and sociology. The challenge that medicine within the modern university faces is how to be pliable to planetary health, and how to use that pliability as an opportunity for new trajectories, without being tempted to denounce its own pliability as a failure to uphold its disciplinary boundaries and principles. Justification for such pliability can arguably be found within medicine's historical folds. Hippocrates (circa 400 BC) is widely considered to be the 'father' of the discipline of medicine, and is credited with pioneering the idea that diseases are caused naturally, rather than because of superstition and gods. Hence, Hippocrates first separated the discipline of medicine from the discipline of religion, arguing that disease was not a punishment inflicted by the gods but rather resulted from a combination of habitat and habits, including diet. According to Kristen et al. (2009), the focal point of Hippocratic medicine is the belief that medicine should be practised as a scientific discipline based on the natural sciences, and on diagnosing and preventing diseases as well as treating them. Moreover, the Hippocratic tradition emphasised the environmental causes and natural treatment of diseases and the need for harmony between the individual and the natural and social environments (Gordon 1990).

In responding to planetary health, the contemporary discipline of medicine needs to embrace its pliability, that is, its ability to evolve and to embrace the notion of health that is present in planetary health—moving beyond the dominant biomedical model of health to embrace this ecosocial approach, first advanced by Hippocrates. The French physician Georges Canguilhem (1943) rejected the idea that there were normal or abnormal states of health. Canguilhem understood health, not as something defined statistically or mechanistically, but as the ability to adapt to one's environment. Arguably, health can therefore be understood as varying for every individual, depending on their circumstances. The elegance of Canguilhem's definition of health—of normality—is that it includes the animate and inanimate environments, as well as the physical, mental, and social dimensions of human life (The Lancet 2009)—it is a planetary approach to health.

5.3 Transversality

Guattari once asserted that "transdisciplinarity must become transversality between science, the social, aesthetics and politics" (Guattari et al. 2015, p. 125). In this section we understand transversality as central to transdisciplinarity and the openness in research and learning. We provide insight into how this transversality operates in relation to disciplinary pliability. Transversality operates across disciplinary boundaries that demarcate and connect disciplines (Cilliers and Nicolescu 2012, pp. 715–716). Van Huyssteen writes that transversality:

> promotes different, non-hierarchical but equally legitimate ways of viewing specific topics, problems, traditions or disciplines, and create[s] the kind of space where different voices need not always be in contradiction, or in danger of assimilating one another, but are in fact dynamically interactive with one another. (2014, p. 214)

Van Huyssteen, and other writers, use the metaphor of the intersection of a line with another line or surface to describe tranversality. Transversality is a:

> lying across, an extending over, a linking together, and an intersecting of various forms of disciplinary discourses, modes of thought and methods. Transversality emerges as a place in time and space where our multiple beliefs and practices, our habits of thoughts and attitudes, our prejudices and assessments, converge. (van Huyssteen 1999, p. 136)

It is a communal space, a communal space that provides opportunity to "identify shared concerns and points of agreement" at the same time as "exposing areas of disagreement and putting into perspective specific divisive issues that need to be discussed" (Van Huyssteen 2006, p. 9). This crossing over locates transdisciplinary work, not in one discipline or another, but in the "transverse spaces" between and beyond disciplines (Van Huyssteen 2006, p. 9). We argue that disciplinary pliability is a key enabler of transversal actions, and that this relationality promotes openness in research and learning.

Van Huyssteen argues that this transversality involves critical engagement with a variety of disciplinary methodologies and epistemologies, starting with "real, situated, embodied, activities and desires of actual agents, not abstract theories, frameworks or methodologies themselves" (Van Huyssteen 2014, p. 254). We differ from van Huyssteen on this point. We argue that transversality moves through disciplinary pliability, be that in health, science, mathematics, religion, planning, law or other disciplines, and engages in the folding of their abstraction and concreteness. Transversality is used in the context of transdisciplinarity to survey the abstraction and concreteness of disciplines. Within the space and time of the transversal action, disciplinary abstraction and concreteness acquire a transdisciplinary actuality to the extent that they become subject to the traversing interpreters, who interpret disciplinary abstractions and concreteness across a multiplicity of disciplines in a manner that reconstitutes them, as the relational product of their transversal action. These interpreters within the context of transdisciplinarity are possibly multiple; it is not that disciplinary specialization needs to be overcome, it is that individuals, communities, and civilization in general need to develop the *complementary* means by which to appropriate all particular expertise, so that we regain our ability, a facility, an adeptness, to take the *whole* into our most profound concern.

The relational products of the transversal action may emerge as a synthesis, a fusion, a mixing, a critique, or a blending of the horizons of abstraction and concreteness of disciplines towards a specific problematization. Over time they may also take radically unexpected turns, in some instances leading to a reproblematization—critical or otherwise—of the original problem, in a manner quite different from any merely interdisciplinary engagement. In this sense transversality has the potential to promote openness of research and learning, both within and across disciplines, by disciplinarians and individuals, communities, and civilization.

To provide insight into transversality we will highlight the broad transversal actions across disciplines that gave rise to planetary health, and the broader understanding of geo-social assemblages on which it is founded. These transversal actions can, for explanatory purposes, be separated into two stages: the first are the implicit instances of transversal action that led to a recent emergence of planetary health; and the second is a more explicit call for transversal actions, through a call for transdisciplinary research and learning from within planetary health (Whitmee et al. 2015). Arguably, the first stage can be contextualized within a broader series of transversal actions across the earth and life science disciplines that have occurred over the last half-century, that moved across geology, and the abstraction and concreteness of its lithospheric imprints which have brought the temporalities, intensities and magnitudes of geologic processes into everyday human life (Alley 2000, pp. 115–122). This is a transversality that has given rise to a geo-social assemblage, which has had consequences across disciplines, where complex physical systems of the earth, its lithosphere, hydrosphere, atmosphere, biosphere, and cryosphere can be understood to have profound relations with the anthroposphere, giving rise to the Anthropocene thesis (Broecker 1987, p. 123; Brooke 2014; Horton et al. 2014; Scheffer et al. 2001, Butler et al. 2015; Clark 2015; DeFries et al. 2012; Demaio and Rockström 2015; Horton and Lo 2015; Kahn et al. 2014; Whitmee et al. 2015; Zalasiewicz et al. 2017).

As the historian John Brooke recounts, the pivotal years of 1966–73 saw the emergence of major new perspectives on the shaping of the geo-social assemblage—each of which built on dissident hypotheses from a number of disciplines. Examples included the thesis that biological evolution is punctuated by catastrophic bursts linked to major geophysical events, and the idea that the different components of the earth function as an integrated system—as expressed in the Gaia hypothesis and earth systems theory (Brooke 2014). As we have previously discussed, these transversal actions across the earth and life science disciplines created an idea of a unified earth, a single, integrated system, which is simultaneously an unstable, multistate earth that can be nudged into an alternative operating state by one of its sub-component species. The evolving geo-social assemblage, and its ongoing reconstitution, have found their way, in recent decades, across geology, biology and atmospheric science, and are becoming detectable in health, religion, law, planning, and the humanities to name only some other disciplines. Planetary health, and the emergence of health systems thinking, are two manifestations of these transversal actions (Chughtai and Blanchet 2017; Whitmee et al. 2015, p. 1997).

The challenge that currently faces those working in planetary health is how to engage with the recent explicit call for transdisciplinary research and learning from planetary health. They are asked to make a conscious decision to take part in transversal actions across disciplines. What we might highlight here as a starting point is that many disciplines that may be engaged through this call, such as law (Burdon 2010, 2012), planning (Enengel et al. 2012; Martin and Beatley 1993), or religion (Ravetz 2008) for example, have already often been involved in the transversal actions that gave birth to planetary health. This call does not limit the possible transversal actions, but provides guidance. It seeks to favour transversal actions that work to regain our ability to take the whole, in this case the evolving geo-social assemblage, into our most profound concern. It seeks to favour experimentation with new paths for the constitution of collective assemblages of enunciation. As Whitmee et al. (2015) notes:

> Understanding non-linear state shifts in ecosystems are very important, but in the absence of improved understanding and predictability of such changes, efforts to improve resilience for human health and adaptation strategies remain a priority. The creation of integrated surveillance systems that collect rigorous health, socio-economic, and environmental data for defined populations over long time periods can provide early detection of emerging disease outbreaks or changes in nutrition and non-communicable disease burden. The improvement of risk communication to policy makers and the public and the support of policy makers to make evidence-informed decisions can be helped by an increased capacity to do systematic reviews and the provision of rigorous policy briefs. (Whitmee et al. 2015)

Furthermore, this call for transversal action to address the challenges of planetary health emphasizes the place of research and learning in the broader social field (Horton 2015a, b, 2016; Horton et al. 2014; Horton and Lo 2015; Kahn et al. 2014). It argues that the execution of programmes of planetary health requires significant contracts for research and social experimentation in the real world that not only involve researchers, but the private sector and government, inhabitants and users, to bring about research and learning as collective awareness:

> Incentivise and provide evidence-based methods to encourage more robust adherence within the private sector than exists at present to high standards of environmental stewardship and health protection and build capacity in private sector entities based in low-income and middle-income settings. Engage civil society and community organisations by promoting public discourse, participation, and transparency of data and systems models to allow monitoring of trends and to encourage polycentric governance building on local capabilities to steward environmental resources and protect health. (Whitmee et al. 2015)

This explicit call through the auspices of planetary health asks us to relearn and research health with a greater openness, through transversal actions across all university disciplines, including those disciplines like religion whose contributions and capacity to inform health have arguably been obscured, overshadowed and subjugated in the twentieth century by biomedical models of health (Porter 1997) that have been fortified within other university disciplines such as medicine. Carrying out such transversal action requires us to look both backwards and forwards to transversal actions across disciplines, such as medicine, science, philosophy and religion. In the ancient world, scientists were often philosophers as well as physicians, and the distinctions between philosophy, religion and medicine were blurred. At its inception, ancient medicine was a branch of natural philosophy. This imbricated history is why such disciplines as religion and medicine arguably share such common aims as the alleviation of human suffering, the optimisation of human life for personal and communal flourishing, and a concern with the common identity of, and equality between, all human beings.

In the Anthropocene, with human culture now a force in nature and threatening the health and wellbeing of future generations (Boyden 2004), we could obtain great value by increasing transversal actions across disciplines such as medicine, philosophy and religion. Such actions enable transformations to sustainable ways of living, tempering the seemingly endless appetite for material consumption that threatens the health of people and planet. These transversal actions challenge us to question the human-centredness of these disciplines, but also present opportunities for new understandings of human flourishing that go beyond the human and include animal, plant and geological modes of being and flourishing. To conclude this section, we highlight just three of the many ways in which religion, both as discipline and practice, is open to these transversal actions. First, planetary health's focus on the *longue durée* and on the interdependence of all systems that are operational on Earth intersects with recent research in cognitive science that identifies religious beliefs and behaviours as prosocial and as a vital innovation in human evolution (Atran and Henrich 2010; Norenzayan et al. 2016). The notion that all societies, regardless of their geographical or historical situation, were religious originally arose from Christian theology and was thus an unverified projection of a particular *type* of religion onto the whole human species (DeRoover 2014). Yet recent research that melds the hard sciences, the social sciences, and traditional humanities has permitted a new and arguably unbiased picture of religion to emerge.

Within this new context religion is seen as a crucial cultural product that ties together the relation of humans to each other, to animal and plant species, and to the entirety of the planet, which depends on the attribution of agency to factors in the environments in which humans live (Barrett 2007; Atran and Henrich 2010; Norenzayan et al. 2016). Second, the transversal actions of planetary health intersect with religious studies perspectives that emphasize the interrelatedness of all things and the emergence of a contemporary phenomenon that Taylor terms "Dark Green Religion" (Taylor 2010). The spiritual perspective identifies ecological flourishing and environmental sustainability as sacred and demands that humans recognize their dependence on, and mutual interdependence with, the whole earth. Its origins lie in the 1960s, when the Anthropocene (though that term was not formally used until the 1980s) was recognized in publications such as biologist Rachel Carson's *Silent Spring* (1962) and historian Lynn White Jnr's "The historical roots of our ecologic crisis" (1967), published in the influential journal *Science*. Both of these publications detailed the loss of biodiversity and damage to the natural environment caused by humans (Cusack 2010). The modern pagan revival since the mid-twentieth century involves the worship of the Earth as a goddess, a spiritual parallel to Lovelock's Gaia hypothesis. Dark Green Religion is an open phenomenon in that it accommodates environmental ethics and activism located within specific religions, and also encompasses those outside formal religious institutions and non-religious actors.

Finally, it is worth highlighting that world religions, despite declining in popularity in the developed world, remain a powerful force in both the developed and developing worlds, and a powerful site for implementing Guattari's liberated notion of research and learning beyond the purified spaces of the university. Given that a majority of the 7 billion human residents of planet earth identify as religious and rely on the advice of religious professionals to make life decisions, the transversal actions of planetary health will arguably benefit from engagement with the concreteness of religious actions and practices. It could be argued that one powerful starting point is that Pope Francis, the global head of the Catholic Church, recently issued the encyclical *Laudato Si': On Care For our Common Home* (2015), in which he urges people to "feel intimately united with all that exists" (Francis 2015, p. 4) in order to bring about change in the way that humans relate to the totality of the earth, their home, and to secure the future of the entire planet.

5.4 Coda

Disciplines are not predetermined, and do not exist in isolation from each other. Disciplines are relational. As we discussed, this relationality has manifested through many qualifying prefixes to which it has been subjected: inter-, multi-, trans-, pluri-, de-, anti-, in-, meta-, post-, trans-. In this chapter we have focused on conceptualising the relationality of disciplinarity with the prefix trans-, providing insights along the way into what this might mean in the broadest sense for the evolution of research and learning. The relationality was explored along two conceptual dimensions: pliability and transversality. By no means do we argue that these are the only conceptual dimensions open to such an examination. We discussed how they generate relationality between disciplinarity and transdisciplinarity, and how they operate as the site of becoming-other for research and learning. We illuminated these aspects of relationality through discussion of the recent emergence of planetary health. Through this example, we highlighted the way in which pliability opened research and learning within the discipline of health, and the role that transversality has played in the formation of the geo-social assemblage that forms the basis of planetary health.

We started with an exploration of the pliability of disciplines. We explained that pliability here is not, and should not be seen as, mere discretionary flexibility. If it were, we would have been offering nothing new and we would keep on reiterating the usual incantations about disciplinary flexibility. Pliability is understood as the paradoxical folding between universality and particularity, between abstraction and a concreteness that flows with, and in a way follows, the world, an entanglement of word and world (Deleuze 1995). Disciplines emerge in 'the middle' of this folding

(Deleuze and Guattari 1987). This idea of pliability resonates with the Deleuzian notion of 'the fold' [*le pli*] as it inheres in the multi-*pli*-cation, im-*pli*-cation, com-*pli*-cation and re-*pli*-cation of the different phenomena encountered in life. Indeed, disciplinary pliability is a necessary and desirable part of the folding, unfolding and refolding of things because, as such, it opens up disciplines and their working to all the possibilities, potential creativity, novelty and differences of worlds yet-to-come. It is through the double folded pliability of disciplines that we argued that transdisciplinarity, in the form of transversal action, operates. Whilst disciplines enact a form of framing between universality and particularity, an entanglement of word and world, transversality moves through these foldings, exploring their relationality across disciplines, through a problematization, not only of disciplinary abstractions but also of their concreteness, to promote a *becoming-other-than-discipline*. To conclude, pliability and transversality keep disciplinarity moving; they help protect disciplinarity from isolation, division, separation and fixity, but do not guarantee such movement.

References

Alley, R. (2000). *The two-mile time machine: Ice cores, abrupt climate change, and our future*. Princeton: Princeton University Press.

Appadurai, A. (1996). Diversity and disciplinarity as cultural artifacts. In C. Nelson & D. Gaonkar (Eds.), *Disciplinarity and dissent in cultural studies* (pp. 23–36). New York: Routledge.

Atran, S., & Henrich, J. (2010). The evolution of religion: How cognitive by-products, adaptive learning heuristics, ritual displays, and group competition generate deep commitments to prosocial religion. *Biological Theory, 5*, 18–30.

Barrett, J. (2007). Cognitive science of religion: What is it and why is it? *Religion Compass, 1*(6), 768–786.

Boyden, S. V. (2004). *The biology of civilisation: Understanding human culture as a force in nature*. Sydney: UNSW Press.

Broecker, W. (1987). Unpleasant surprises in the greenhouse. *Nature, 328*, 123–126.

Brooke, J. (2014). *Climate change and the course of global history: A rough journey*. New York: Cambridge University Press.

Burdon, P. (2010). The rights of nature: Reconsidered. *Australian Humanities Review, 49*, 1.

Burdon, P. (2012). A theory of earth jurisprudence. *Australian Journal of Legal Philosophy, 37*, 28–60.

Butler, C., Dixon, J., & Capon, A. (Eds.). (2015). *Health of people, places and planet. Reflections based on Tony McMichael's four decades of contribution to epidemiological understanding*. Canberra: ANU Press.

Canguilhem, G. (1943). *The normal and the pathological* (C. R. Fawcett & R. S. Cohen, 1991, Trans.). New York: Zone Books.

Capon, A. (2017). Harnessing urbanisation for human wellbeing and planetary health. *Journal of Planetary Health, 1*(1), e6–e7.

Carson, R. (1962). *Silent spring*. Boston: Houghton Mifflin.

Chughtai, S., & Blanchet, K. (2017). Systems thinking in public health: A bibliographic contribution to a meta-narrative review. *Health Policy and Planning, 32*, 585–594.

Cilliers, P., & Nicolescu, B. (2012). Complexity and transdisciplinarity – Discontinuity, levels of reality and the hidden third. *Futures, 44*(8), 711–718. https://doi.org/10.1016/j.futures.2012.04.001.

Clark, H. (2015). Governance for planetary health and sustainable development. *The Lancet, 386*(10007), e39–e41. https://doi.org/10.1016/S0140-6736(15)61205-3.

Cusack, C. M. (2010). The church of all worlds and pagan ecotheology: Uncertain boundaries and unlimited possibilities. *Diskus* 11. At: http://jbasr.com/basr/diskus/diskus10/index.html.

DeFries, R. S., Ellis, E. C., Chapin, F. S., Matson, P. A., Turner, B. L., Agrawal, A., et al. (2012). Planetary opportunities: A social contract for global change science to contribute to a sustainable future. *Bioscience, 62*(6), 603–606. https://doi.org/10.1525/bio.2012.62.6.11.

Deleuze, G. (1995). *Negotiations, 1972–1990*. New York: Columbia University Press.

Deleuze, G. (2006). *The fold: Leibniz and the Baroque* (Rev. ed.). London/New York: Continuum.

Deleuze, G., & Guattari, F. (1987). *A thousand plateaus: Capitalism and schizophrenia*. Minneapolis: University of Minnesota Press.

Demaio, A. R., & Rockström, J. (2015). Human and planetary health: Towards a common language. *The Lancet, 386*(10007), e36–e37. https://doi.org/10.1016/S0140-6736(15)61044-3.

DeRoover, J. (2014). Incurably religious? Consensus gentium and the cultural universality of religion. *Numen, 61*, 5–32.

Després, C., Vachon, G., & Fortin, A. (2011). *Implementing transdisciplinarity: Architecture and urban planning at work*. Dordrecht: Springer.

Enengel, B., Muhar, A., Penker, M., Freyer, B., Drlik, S., & Ritter, F. (2012). Co-production of knowledge in transdisciplinary doctoral theses on landscape development – An analysis of actor roles and knowledge types in different research phases. *Landscape and Urban Planning, 105*(1–2), 106–117. https://doi.org/10.1016/j.landurbplan.2011.12.004.

Fam, D., Kelly, S., Leimbach, T., Hitchens, L., & Callen, M. (2018). Meta-considerations for planning, introducing and Standardising collective learning in higher degree institutions. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Foucault, M. (1973). *The order of things: An archaeology of the human sciences*. New York: Vintage Books.

Foucault, M. (1979). *Discipline and Punish. The birth of the prison* (A. Sheridan, Trans. Vintage Books ed.). New York: Random House Inc.

Foucault, M. (1991). Space, knowledge and power. In P. Rabinow (Ed.), *The Foucault reader: An introduction to Foucault's thought* (pp. 239–256). New York: Penguin Group.

Francis (Pope). (2015). *Laudato Si': On care for our common home.* Rome: The Holy See.

Gordon, S. (1990). Holistic medicine and mental health practice: Toward a new synthesis. *American Journal of Orthopsychiatry, 60*, 357–371.

Guattari, F., Osborne, P., Sandford, S., & Alliez, É. (2015). Transdisciplinarity must become transversality. *Theory, Culture & Society, 32*(5–6), 131–137. https://doi.org/10.1177/0263276415597045.

Haines, A., Whitmee, S., & Horton, R. (2015). Planetary health: A call for papers. *The Lancet, 384*(9942), 479–480. https://doi.org/10.1016/S0140-6736(14)61289-7.

Hawkins, K. (1984). *Environment and enforcement: Regulation and the social definition of pollution*. Oxford: Oxford University Press.

Horton, R. (2015a). Offline: Progress towards planetary health. *The Lancet, 385*(9965), 314. https://doi.org/10.1016/S0140-6736(15)60093-9.

Horton, R. (2015b). Offline: Why the unity of life matters for our planetary health. *The Lancet, 386*(9991), 323. https://doi.org/10.1016/S0140-6736(15)61291-0.

Horton, R. (2016). Offline: Planetary health – Where next? *The Lancet, 387*(10028), 1602. https://doi.org/10.1016/S0140-6736(16)30196-9.

Horton, R., & Lo, S. (2015). Planetary health: A new science for exceptional action. *The Lancet, 386*(10007), 1921–1922. https://doi.org/10.1016/S0140-6736(15)61038-8.

Horton, R., Beaglehole, R., Bonita, R., Raeburn, J., McKee, M., & Wall, S. (2014). From public to planetary health: A manifesto. *The Lancet, 383*(9920), 847. https://doi.org/10.1016/S0140-6736(14)60409-8.

Kahn, L. H., Kaplan, B., Monath, T., Woodall, J., & Conti, L. (2014). A manifesto for planetary health. *The Lancet, 383*(9927), 1459. https://doi.org/10.1016/S0140-6736(14)60709-1.
Kelley, D. (Ed.). (1997). *History and the disciplines: The reclassification of knowledge in early modern Europe*. Rochester: University of Rochester Press.
Kirsten, T., Van der Walt, H., & Viljoen, C. (2009). Health, well-being and wellness: An anthropological eco-systemic approach. *Health SA Gesondheid, 14*, 149–155.
Lang, T., & Rayner, G. (2012). Ecological public health: The 21st century's big idea? An essay by Tim Lang and Geof Rayner. *British Medical Journal, 345*, 1–5.
Latour, B. (2010). *The making of law: An ethnography of the Conseil d'Etat*. Cambridge/Malden: Polity.
Loubser, G. (2015). Becoming transdisciplinary theologians: Wentzel van Huyssteen, Paul Cilliers and Constantine Stanislavski. *Theological Studies, 71*(3), 1–9.
Luhmann, N., Ziegert, K. A., & Kastner, F. (2008). *Law as a social system*. New York: Oxford University Press.
Martin, E., & Beatley, T. (1993). Our relationship with the earth: Environmental ethics in planning education. *Journal of Planning Education and Research, 12*(2), 117–126. https://doi.org/10.1177/0739456x9301200207.
McLaren, L., & Hawe, P. (2005). Ecological perspectives in health research. *Journal of Epidemiology and Community Health, 59*(1), 6–14. https://doi.org/10.1136/jech.2003.018044.
McLeroy, L., Bibeau, D., Steckler, A., & Glanz, K. (1988). An ecological perspective on health promotion programs. *Health Education Quarterly, 15*(4), 351–377.
McMichael, A. J. (1993). *Planetary overload: Global environmental change and the health of the human species*. Cambridge: Cambridge University Press.
Messer-Davidow, E., Shumway, D., & Sylvan, D. (Eds.). (1993). *Knowledges: Historical and critical studies in disciplinarity*. Charlottesville: University Press of Virginia.
Nicolescu, B. (2002). *Manifesto of transdisciplinarity*. Albany: State University of New York Press.
Norenzayan, A., Sharriff, A. F., Gervais, W. M., Willard, A. K., McNamara, R., Slingerland, E., & Henrich, J. (2016). The cultural evolution of prosocial religion. *Behavioural and Brain Sciences, 39*, 1–19.
Philippopoulos-Mihalopoulos, A. (2012). Mapping the lawscape: Spatial law and the body. In Z. Bankowski, M. Del Mar, & P. Maharg (Eds.), *Beyond text in legal education*. Edinburgh: Edinburgh University Press.
Philippopoulos-Mihalopoulos, A. (2013). Atmospheres of law: Senses, affects, lawscapes. *Emotion, Space and Society, 7*, 35–44.
Porter, R. (1997). *The greatest benefit to mankind. A medical history of humanity from antiquity to the present*. London: Harper Collins.
Ravetz, J. (2008). Gaia's revenge: Climate change and humanity's loss. *Futures, 40*(3), 305–307.
Rizzo, A., & Galanakis, M. (2015). Transdisciplinary urbanism: Three experiences from Europe and Canada. *Cities, 47*, 35–44. https://doi.org/10.1016/j.cities.2015.01.001.
Scheffer, M., Carpenter, S., Foley, J., Folkes, C., & Walker, B. (2001). Catastrophic shifts in ecosystems. *Nature, 413*, 591–596.
Smith, H., & Jenkins, P. (2015). Trans-disciplinary research and strategic urban expansion planning in a context of weak institutional capacity: Case study of Huambo, Angola. *Habitat International, 46*, 244–251. https://doi.org/10.1016/j.habitatint.2014.10.006.
Taylor, B. (2010). *Dark green religion: Nature spirituality and the planetary future*. Berkeley/Los Angeles/London: University of California Press.
The Lancet. (2009). What is health? The ability to adapt. *Lancet, 373*, 781.
Valenza, R. (2009). *Literature, language, and the rise of the intellectual disciples in Britain* (pp. 1680–1820). Cambridge: Cambridge University Press.
Van Huyssteen, J. (1999). *The shaping of rationality: Toward interdisciplinarity in theology and science*. Grand Rapids: Eerdmans.

Van Huyssteen, J. (2006). *Alone in the world? Human uniqueness in science and theology*. Grand Rapids: Eerdmans.

Van Huyssteen, J. (2014). Postfoundationalism in theology: The structure of theological solutions. *Ephemerides Theologicae Lovanienses, 90*(2), 209–229.

Wade, D. T., & Halligan, P. W. (2004). Do biomedical models of illness make for good healthcare systems? *British Medical Journal, 329*, 1398–1401.

White, L. (1967). The Historical Roots of Our Ecologic Crisis. *Science, 155*, 1203.

Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., & Yach, D. (2015). Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet, 386*(10007), 1973–2028. https://doi.org/10.1016/S0140-6736(15)60901-1.

Zalasiewicz, J., Steffen, W., Leinfelder, R., Williams, M., & Waters, C. (2017). Petrifying earth process: The stratigraphic imprint of key earth system parameters in the Anthropocene. *Theory, Culture & Society, 34*(2–3), 83–104.

Chapter 6
The Transdisciplinary Evolution of the University Condition for Sustainable Development

Basarab Nicolescu

6.1 Introduction: Disciplinarity, Multidisciplinarity, Interdisciplinarity and Transdisciplinarity

The indispensable need for *bridges* between the different disciplines is attested to by the emergence of pluridisciplinarity and interdisciplinarity around the middle of the twentieth century. *Pluridisciplinarity concerns studying a research topic not in only one discipline but in several at the same time*. For example, a painting by Giotto can be studied not only within art history but within history of religions, European history, and geometry. Or else Marxist philosophy can be studied with a view to blending philosophy with physics, economics, psychoanalysis or literature. The topic in question will ultimately be enriched by blending the perspectives of several disciplines. Moreover, our understanding of the topic in terms of its own discipline is deepened by a fertile multidisciplinary approach. Multidisciplinarity brings a *plus* to the discipline in question (the history of art or philosophy in our examples), but this "plus" is always in the exclusive service of the home discipline. In other words, the multidisciplinary approach overflows disciplinary boundaries while *its goal remains limited to the framework of disciplinary research*.

Interdisciplinarity has a different goal from multidisciplinarity. *It concerns the transfer of methods from one discipline to another*. One can distinguish three degrees of interdisciplinarity: (a) *a degree of application*—for example, when the methods of nuclear physics are transferred to medicine, this leads to the appearance of new treatments for cancer; (b) *an epistemological degree*—for example, transferring methods of formal logic to the area of general law generates some interesting analyses of the epistemology of law; (c) *a degree of the generation of new disciplines*—for example, when methods from mathematics were transferred to physics, mathematical physics was generated, and when they were transferred to

B. Nicolescu (✉)
Centre International de Recherches et Etudes Transdisciplinaire (CIRET), Paris, France

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_6

meteorological phenomena or stock market processes they generated chaos theory; transferring methods from particle physics to astrophysics produced quantum cosmology; and from the transfer of computer methods to art computer art was derived. Like pluridisciplinarity, interdisciplinarity overflows the disciplines but *its goal still remains within the framework of disciplinary research*. It is through the third degree that interdisciplinarity contributes to the disciplinary big bang.

As the prefix "trans" indicates, *transdisciplinarity* concerns that which *is* at once *between* the disciplines, *across* the different disciplines, and *beyond* all discipline. Its goal is *the understanding of the present world*, of which one of the imperatives is the unity of knowledge.

Is there something between and across the disciplines and beyond all disciplines? In the presence of several levels of Reality the space between disciplines and beyond disciplines is full, just as the quantum vacuum is full of all potentialities: from the quantum particle to the galaxies, from the quark to the heavy elements which condition the appearance of life in the universe. The discontinuous structure of the levels of Reality determines *the discontinuous structure of transdisciplinary space*, which in turn explains why transdisciplinary research is radically distinct from disciplinary research, even while being entirely complementary. *Disciplinary research concerns, at most, one and the same level of Reality*; moreover, in most cases, it only concerns fragments of one level of Reality. *Transdisciplinarity,* on the other hand, *concerns the dynamics engendered by the action of several levels of Reality at once*. The discovery of these dynamics necessarily passes through disciplinary knowledge. While not a new discipline or a new superdiscipline, transdisciplinarity is nourished by disciplinary research; in turn, disciplinary research is clarified by transdisciplinary knowledge in a new, fertile way. In this sense, disciplinary and transdisciplinary research are not antagonistic but complementary.

Disciplinarity, multidisciplinarity, interdisciplinarity and transdisciplinarity are like four arrows shot from but a single bow: knowledge.

As in the case of disciplinarity, transdisciplinary research is not antagonistic but complementary to multidisciplinary and interdisciplinary research. Transdisciplinarity is nevertheless radically distinct from multidisciplinarity and interdisciplinarity because of its goal, the understanding of the present world, which cannot be accomplished in the framework of disciplinary research. The goals of multidisciplinarity and interdisciplinarity always remain within the framework of disciplinary research. If transdisciplinarity is often confused with interdisciplinarity and multidisciplinarity (and by the same token, we note that interdisciplinarity is often confused with multidisciplinarity) this is explained in large part by the fact that all three overflow disciplinary boundaries. This confusion is harmful to the extent that it functions to hide the different goals of these three new approaches.

The three pillars of transdisciplinarity—levels of Reality, the logic of the included middle, and complexity—determine *the methodology of transdisciplinary research*. They emerge from the most advanced contemporary sciences, especially quantum physics, quantum cosmology and molecular biology.

Transdisciplinarity is globally open. Levels of Reality are inseparable from levels of perception, and levels of perception form the foundations for the verticality of degrees of transdisciplinarity. Transdisciplinarity entails both a new vision and a lived experience. It is a way of self-transformation oriented towards the knowledge of the self, the unity of knowledge, and the creation of a new art of living.

6.2 The Transdisciplinary Evolution of Education

The emergence of a new culture capable of contributing to the elimination of the tensions menacing life on our planet will be impossible without a new type of education which takes into account *all* the dimensions of the human being.

All the various tensions—economic, cultural, spiritual—are inevitably perpetuated and deepened by a system of education founded on the values of another century, and by a rapidly accelerating unbalance between contemporary social structures and the changes which are currently taking place in the contemporary world.

In spite of the enormous diversity of the systems of education from one country to another, the globalization of the challenges of our era involves the globalization of the problems of education. The different upheavals continually traversing the area of education in one or another country are only symptoms of one and the same flaw: the disharmony which exists between the values and the realities of a planetary life in the process of change. Most certainly, while there is not some miraculous recipe, there is nevertheless a *common centre of questioning* which it would behoove us not to hide if we truly want to live in a more harmonious world.

The recent UNESCO report of the "Commission internationale sur l'éducation pour le vingt et unième siècle", chaired by Jacques Delors, strongly emphasized four pillars of a new kind of education: learning to know, learning to do, learning to live together with, and learning to be. In this context, the transdisciplinary approach can make an important contribution to the advent of this new type of education.

Learning to know means first of all training in the methods which help us distinguish what is real from what is illusory, and to have intelligent access to the fabulous knowledge of our age. In this context *the scientific spirit*, one of the highest ever states attained in the human adventure, is indispensable. It is not the assimilation of an enormous mass of scientific knowledge which gives access to the scientific spirit, but the quality of that which is taught. And here, *quality* means to lead the student into the very heart of the scientific approach which is permanent questioning in relation with the resistance to facts, images, representations, and formalizations.

Learning to know also means being capable of establishing *bridges*—between the different disciplines, and between these disciplines and meanings and our interior capacities. This transdisciplinary approach will be an indispensable complement to the disciplinary approach, because it will mean the emergence of *continually connected beings* who are able to adapt themselves to the changing exigencies of professional life, and who are endowed with a permanent flexibility which is always oriented towards the actualization of their interior potentialities.

Learning to do certainly means acquiring a profession. The acquisition of a profession necessarily passes through a phase of specialization. However, in our tumultuous world, in which the tremendous changes induced by the computer revolution are but the portent of other still more tremendous changes to come, any life which is frozen into one and the same occupation can be dangerous, because it risks leading to unemployment, to exclusion, to a debilitating alienation. Excessive specialization should be outlawed in a world which is in rapid change. If one truly wants to reconcile the exigency of competition and concern for equal opportunity for all human beings, in the future, every profession should be an authentically woven occupation, an occupation which would bind together in the interior of human beings threads linking them to other occupations. Of course, it is not simply a question of acquiring several competencies at the same time but of creating a flexible, interior core which can quickly provide access to another occupation should it become necessary or desirable.

In this context, the transdisicplinary approach can be invaluable. In the last analysis, “learning to do” is an apprenticeship in *creativity*. “To make” also signifies discovering novelty, creating, bringing to light our creative potentialities.

Creating the conditions for the emergence of authentic *persons* involves ensuring the existence of the conditions needed for the maximal realization of their creative potentialities. The social hierarchy, so frequently arbitrary and artificial, could thus be replaced by the cooperation of *structural levels in the service of personal creativity*. Rather than being levels imposed by a competition which does not take the interior being into account at all, these levels would in fact be *levels of being*. The transdisciplinary approach is based on the equilibrium between the exterior person and the interior person. Without this equilibrium, “to make” means nothing other than “to submit.”

“To live together with” does not mean simply tolerating the other’s differences of opinion, skin color, and beliefs; submitting to the exigencies of power; negotiating between the ins and outs of innumerable conflicts; or definitively separating interior from exterior life. The transcultural, transreligious, transpolitic and transnational attitude can be learned. To the extent that in each being there is a sacred, intangible core, it is innate. Yet, if this innate attitude is only potential, it can forever remain non-actualized, absent in life and in act. For the norms of a collectivity to be respected, they must be *validated* by the interior experience of each being. The transcultural, transreligious, transpolitical and transnational attitude permits us to better understand our own culture, to better defend our national interests, to better respect our own religious or political convictions. Just as in all other areas of Nature and knowledge, open unity and complex plurality are not antagonists.

Learning to be appears at first like an insoluble enigma. We know to exist but how can we learn *to be?* We can begin by learning that the word “exist” means, for us: discovering our conditioning, discovering the harmony or disharmony between our individual and social lives, testing the foundations of our convictions in order to discover that which is found underneath. To question, to question always; here also, the scientific spirit is a precious guide for us.

Learning to be is also a permanent apprenticeship in which teachers inform the students as much as students inform the teachers. *The shaping of a person inevitably passes through a trans-personal dimension.* Disrespect for this necessary process goes a long way towards explaining the reason for one of the fundamental tensions of our era, that between the material and the spiritual.

There is one very obvious interrelation between the four pillars of the new system of education: how to learn to make while learning to know, and how to learn to be while learning to live together with? In the transdisciplinary vision, there is a *transrelation* which connects the four pillars of the new system of education, and which has its source in our own constitution as human beings. A viable education can only be an *integral education of the human being*—an education which is addressed to open totality of the human being and not to just one of its components.

At present, education privileges the intellect, relative to sensibility and the body. This was certainly necessary in the previous era, in order to permit the explosion of knowledge. But this privileging, if it continues, sweeps us away in the mad logic of efficiency for efficiency's sake which can only end in our self-destruction.

The recent experiments made by the Nobel Prize-winning physicist Leon Lederman with children from the most disadvantaged neighborhoods of Chicago demonstrates what we have been saying. The Chicago experiment shows well that the intelligence assimilates knowledge much better and much more rapidly when this knowledge is also *understood* with the body and feeling.

This is a prototype of the emergence of a new type of intelligence, founded on an equilibrium between analytic intelligence, feeling, and the body. It is only in this way that the society of the twenty-first century can reconcile effectivity and affectivity. It is quite obvious that the various areas and ages of life call for extremely diverse transdisciplinary methods. Even if transdisciplinary education is a long-term, global process, it is still important to discover and to create places which help to initiate this process and ensure its development.

The University is the privileged place for an education geared towards the exigencies of our time which would also be the pivotal place for an education directed not only towards children and adolescents but also towards adults. Instilling complex and transdisciplinary thought into the structures and programmes of the University will permit its evolution towards its somewhat forgotten mission today—*the study of the universal.* In addition, the University could become the privileged place of apprenticeship in the transcultural, transreligious, transpolitical and transnational attitude, of the dialogue between art and science, which is the axis of a reunification between scientific culture and artistic culture. A renewed University would become the place for welcoming a new kind of humanism.

In spite of extremely varied conditions between universities from one country to another, the disorientation of the University has become worldwide. A number of symptoms function to conceal the general cause of this disorientation: the loss of meaning and the universal hunger for meaning. Transdisciplinary education can open the way towards the integral education of the human being which necessarily transmits the quest for meaning.

The break between science and culture, which manifested itself over three centuries ago, is one of the most dangerous. On the one hand, there are the holders of pure, hard knowledge; on the other, the practitioners of ambiguous, soft knowledge. This break is inevitably reflected in the functioning of universities which favor the accelerated development of scientific culture at the cost of the negation of the subject and the decline of meaning. Everything must be done in order to reunite these two artificially antagonistic cultures—scientific culture and literary or artistic culture—so that they will move beyond to a new transdisciplinary culture, the preliminary condition for a transformation of mentalities.

The University is threatened, not only by the absence of meaning, but also by the refusal to share knowledge. The information circulating in cyberspace generates a historically unprecedented richness. Taking into account present developments, it is nevertheless possible that the "information poor" will become increasingly poor, and the "information rich" will become increasingly rich. One of the goals of transdisciplinarity is research into the steps which are necessary for adapting the University to the cyber-era. *The University must become a free zone of cyber-space-time.*

Universal sharing of knowledge cannot take place without the emergence of a new tolerance founded on the transdisciplinary attitude, one which implies putting into practice the transcultural, transreligious, transpolitic, and transnational vision, from which there arises the direct and indisputable relation between peace and transdisciplinarity.

6.3 Proposals

Recently the Centre Intarnational de Recherches et d'Etudes Transdisciplinaires (CIRET) elaborated, in collaboration with UNESCO, the project *The Transdisciplinary Evolution of the University*. The CIRET-UNESCO project was discussed at the International Congress *Which University for tomorrow?* (Monte Verità, Locarno, Switzerland, April 30–May 2, 1997), sponsored by UNESCO and the Department of Education and Culture of the Republic and Canton of Ticino. Here, I will sketch some of the proposals contained in the *Declaration of Locarno,* adopted by the participants at this congress:

Creation of Institutes of the Research for Meaning
The most complex key problem of the transdisciplinary evolution of the University is that of the teaching of teachers. Universities could fully contribute to the creation and operation of *bona fide* "*Institutes of the Research for Meaning"* which, in their turn, would inevitably have beneficial effects on the survival, the life, and the positive influence of universities.

1. Time for transdisciplinarity
   It is recommended to university authorities (presidents, heads of departments, etc.) to devote 10% of the teaching time in each discipline to transdisciplinarity.

2. Creation of ateliers of transdisciplinary research

   Universities should create ateliers of transdisciplinary research (free from any ideological, political, or religious control) comprising researchers from all disciplines. It is a matter of gradually introducing researchers and creators, exterior to the University including musicians, poets, and artists of high caliber, in specific University projects, with a view to establishing academic dialogue between different cultural approaches. Co-direction of each atelier will be ensured by a teacher in the exact sciences and a teacher in the human sciences or arts, each of these being elected by an open process of co-optation.
3. Creation of centres of transdisciplinarity orientation

   Centres of transdisciplinary orientation will be destined to foster vocations, and to enable the discovery of hidden possibilities in each person; at present, the equality of the potential of the students strongly clashes with the inequality of their possibilities.
4. Transdisciplinarity and cyberspace: pilot ateliers

   It is recommended that universities encourage and develop all available technical means with an eye towards giving emergent transdisciplinary education the requisite universal dimension and, more generally, it is recommended that decision-makers promote the public domain of information (the virtual memory of the world, the information produced by governmental organizations, as well as the information linked to the regulations of *copyleft*).

   In this respect, it is highly recommended that pilot experiences be developed which are founded on the extension of networks, such as the Internet, and the education of the future be "invented" by ensuring planetary activity in continuous feedback, thereby establishing interactions on the universal level for the first time.
5. Creation of an itinerant UNESCO chair and of a transdisciplinary doctoral thesis

   It is recommended that UNESCO create an itinerant chair, if possible in collaboration with the University of the United Nations (Tokyo), which will organize lectures involving the entire community, and that the entire community is informed about transdisciplinary ideas and methods. This chair could be supported by the creation of an Internet site which would prepare the international and university community for a theoretical and practical discovery of transdisciplinarity. The aim is to put everything in place so that the seeds of complex thought and transdisciplinarity can penetrate the structures and programmes of the University of tomorrow. Doctoral theses in subjects with a clear transdisciplinary orientation have to be allowed. This transdisciplinary PhD could have the imprimatur of both the relevant university and of UNESCO.
6. Development of responsibility

   It is recommended that universities make an appeal in the framework of a transdisciplinary approach, notably to a philosophy of Nature, a philosophy of History, and epistemology, with the goal of developing creativity and the meaning of responsibility in leaders of the future. Universities must introduce courses at all levels in order to sensitize students and awaken them to the harmony between beings and things. These courses should be founded on the history of science and technology as well as on the great multidisciplinary themes of today (especially cosmology and general biology) in order to accustom students to thinking about things with clarity and in their context, with an eye to industrial development and technological innovation, and in order to ensure that applications will not contradict an ethics of responsibility vis a vis, other human beings and the environment.

7. Transdisciplinary forums

   In order to reconcile two artificially antagonistic cultures—scientific culture and literary or artistic culture—and to make mentalities evolve, it is recommended that universities organize transdisciplinary forums on subjects including history, philosophy, and sociology of science and the history of contemporary art.

8. Pedagogical innovation and transdisciplinarity

   It is essential to follow-up on the results of experiences bearing witness to strictly pedagogical innovations linked to the transdisciplinary approach in teaching. Universities should encourage and stimulate publications which record and analyze the major examples of innovative experience.

9. Regional ateliers and transcultural internet forums

   It would be necessary that universities organize regional ateliers for transdisciplinary research which include the application of the transcultural, transreligious, transpolitical and transnational vision. Special effort must be made so that some of these ateliers take place in, or in close collaboration with, the universities of developing countries.

   Of particular interest would be the organization by universities of Internet moderated forums with teachers and students from countries involved in religious, cultural, political or national conflicts. The transdisciplinary approach is also a science and an art of dialogue.

6.4 Conclusions

If the universities intend to be valid actors in sustainable development, they have first to recognize the emergence of a new type of knowledge: transdisciplinary knowledge. The new production of knowledge implies a necessary multidimensional opening of the University:

- towards civil society
- towards the other places of production of the new knowledge (private institutions and laboratories, industrial companies, non-profit organizations etc.)

- towards cyber-space-time
- towards the aim of universality
- towards a redefinition of values governing its own existence.

Acknowledgement This paper was presented at the International Association of Universities (IAU)[1] Fourth Mid-Term conference 'The Universities' Responsibilities to Society', held at Chulalongkorn University, Bangkok, Thailand, 12–14 November 1997.

[1] Talk at the International Congress "Universities' Responsabilities to Society", International Association of Universities, Chulalongkorn University, Bangkok, Thailand, November 12–14, 1997.

Part II
Transdisciplinary Learning (Education)

Chapter 7
Meta-considerations for Planning, Introducing and Standardising Inter and Transdisciplinary Learning in Higher Degree Institutions

Dena Fam, Tania Leimbach, Scott Kelly, Lesley Hitchens, and Michelle Callen

7.1 Introduction

The traditional model of tertiary education has not changed since the Second World War. Over this 70-year period, universities have focused on the creation of distinct faculties dedicated to the delivery of 3- to 5-year disciplinary programmes for graduate and postgraduate students. They have relied upon staff with disciplinary expertise to deliver core and elective subjects, and the methods for teaching and learning have revolved around lectures, tutorials, assessments and exams.

Across the world, universities and tertiary education institutes now exist in a rapidly shifting landscape. Complex forces, including immense and ongoing technological change, increasing environmental pressures and vastly different work environments, are transforming the contexts in which they must operate. While dissertations, diplomas and degrees continue to be the principal business of most universities, institutions worldwide are investing in the development of innovative models for both interdisciplinary and transdisciplinary education. These new models often reflect a challenge- or problem-driven model of learning, and it has been argued they are better suited to preparing students for the needs and realities of the contemporary world (Golding 2009; Klein 2010; Mulgan et al. 2016). Schneider and Shoenberg (1998) have characterized the most recent period in higher education as a time of transformative change. They claim this period has not completely altered the landscape, but nonetheless, change is emerging in and around the old

D. Fam (✉) · T. Leimbach · S. Kelly
Institute for Sustainable Futures, University of Technology Sydney, Ultimo, NSW, Australia
e-mail: Dena.Fam@uts.edu.au

L. Hitchens
Faculty of Law, University of Technology Sydney, Sydney, NSW, Australia

M. Callen
Strategy and Communications, Vice Chancellor's Office, University of Technology Sydney, Sydney, NSW, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_7

academy (Klein 2010). This transformation "comprises new forms of scholarship and modes of teaching and learning, reconfigurations of disciplines, and a new relational pluralism" (Minnich 1995).

There are a number of added drivers influencing the push for universities to change traditional models of learning. The rising costs of higher education for students, and the increased expectations they have of learning experiences and course delivery, as well as decreased government funding, mean that competition between institutions for students is becoming fierce. New competitors have emerged ranging from independent research institutes, online teaching and learning organizations and think tanks (Mulgan et al. 2016). Corporations are offering bespoke qualifications to professionals who can access short courses online at minimal cost, and the growing prominence of MOOCs (Massive Online Open Courses) has disrupted traditional delivery models. Furthermore, the rise of online, digital resources has led to changing perceptions about the style of university teaching and learning, with the sense that universities should provide more than lecture-based disciplinary content. Universities must now address how they add value to disciplinary degrees in order to remain relevant in a changing learning environment as well as respond to the needs of employers who are demanding more than subject knowledge from new graduates, including applied knowledge, critical thinking and sophisticated communication skills (Hart Research Associates 2015).

In response to these drivers, there has been an increasing trend in educational institutions globally toward the development of integrative curricula, the crossing of the boundaries between disciplinary fields, new methods of teaching and learning, and a focus on problem- or theme-based learning. This is shifting the role of curricula from the mastery of disciplinary content to the critical integration of multiple bodies of knowledge relative to a specific question (Holley 2009). However, there is still a significant gap between the rhetoric and endorsement of working across disciplinary boundaries and the realities of campus life (Klein 2010). While change is occurring on many campuses, there is also clear evidence of resistance, and as Henry (2005) warns, new rounds of disciplinary hegemony continue to challenge interdisciplinary ascendancy. New initiatives are often vulnerable due to a lack of high-level support, and many survive on the margins, without deep roots, or adequate budgets, tenure lines and spaces. Similar barriers across administrative, funding and cultural domains are evident in the area of interdisciplinary and transdisciplinary education where research suggests that initiatives are routinely stymied (Klein 2010). Resistance and uncertainty endures, resulting in tertiary institutions that remain dedicated to the delivery of discrete disciplinary programmes.

In this chapter, we examine a process of identifying the barriers to, and opportunities for, planning, introducing and standardising postgraduate degrees that cross disciplinary boundaries within the context of an Australian university. The specificities of this exemplar will contribute to a growing body of knowledge and lessons learned in implementing interdisciplinary and transdisciplinary degrees and associated institution-wide change.

7.2 Defining Integrative Approaches to Teaching and Learning

There are several terms used to describe integrative approaches to research, teaching and learning. The most prominent terms include cross-disciplinarity, multidisciplinarity, interdisciplinarity and transdisciplinarity (Tress et al. 2005). Collectively these terms have been referred to as integrative approaches, whether for education, research, or project-based work. Within the literature these terms are frequently used interchangeably and are often applied inconsistently across different disciplines. (Tress et al. 2005) argues that the lack of a common understanding of these terms has resulted in negative consequences which have hindered the success of integrative methods and approaches. In practice however, providing consistent definitions for what these terms actually represent has proved difficult, and their meanings depend on the contexts in which they are used. For example, the definition of interdisciplinarity differs depending upon whether it is approached from a research context or a teaching and learning context. Klein (2017) suggests that such terms are often used as buzzwords, replacing informed arguments with superficial aphorisms such as “everyone is interdisciplinary today”. For these reasons it is important to define what is meant when these terms are used and applied, particularly when used within an educational context.

The most common definitions for these terms reflect a research or project-based context, but fall short when applied within a teaching and learning context. For example, *multidisciplinarity* is used when more than one discipline is making a contribution to one theme or problem but continue to work within distinct aspects of the problem. Participants exchange knowledge but do not cross disciplinary boundaries, so the creation of new knowledge remains within disciplinary fields. From an educational perspective, this might mean that a student undertakes a joint degree from two unrelated disciplines such as engineering and law.

The term interdisciplinarity can be defined in its root form. In this chapter we have based our definition on two authoritative sources: National Academy of Sciences (NAS) report, Facilitiating Interdisciplinary Research (2004) and Klein and Newell (1997) in the Handbook of the Undergraduate Curriculum. Here, interdisciplinarity involves two or more academic disciplines working together and crossing disciplinary boundaries to integrate information, data, techniques, tools, perspectives, concepts and/or theories to solve a common research goal that is beyond the scope of a single discipline or area of research. The practice of interdisciplinarity therefore involves tackling complex problems where researchers from different disciplines meet at the interface of those disciplines and cross frontiers to form new perspectives. Interdisciplinary practitioners often retain strong subject expertise but integrate knowledge, methods and theories along the way. The term *transdisciplinarity* aims to integrate knowledge from academic and non-academic participants in a collaborative search for a common goal and new knowledge and theory. Tress et al. (2005) argue that transdisciplinarity combines interdisciplinarity with a participatory approach that is inclusive of academic and non-academic participants, and that new knowledge and theory emerges from the *integration* of these diverse knowledge perspectives. However, this definition falls short when used in an educational context, as participatory approaches may already be used within both disciplinary and interdisciplinary education. Therefore, the use of 'participatory approaches' is a necessary but not a sufficient condition for defining transdisciplinarity within an educational context. Klein (2018, Chap. 2 of this book) suggests that the "prefix 'inter' is usually associated with blending or linking existing approaches, while the prefix 'trans' connotes transcending them through an overarching set of axioms associated historically with unity of knowledge". In attempting to visualize these perspectives, we have developed a graphic representation for what integrative approaches represent within an educational context (see Fig. 7.1 below).

Figure 7.1 depicts the transition from a traditional disciplinary approach to a transdisciplinary approach to teaching and learning. These classifications are by no means discrete, but represent an amorphous transition along a spectrum of integrative sciences (as shown by the blended downward-facing arrow on the right). In a standard *disciplinary approach,* teaching and learning remain bounded by disciplinary subjects. Each student takes subjects that fit neatly within their disciplinary domain. In a *multidisciplinary approach,* students may form multidisciplinary teams to solve a common problem or to explore a theme, but largely contribute to an area of research by remaining within their own area of expertise. In a team-based multidisciplinary approach, the opportunity for learning new methods and

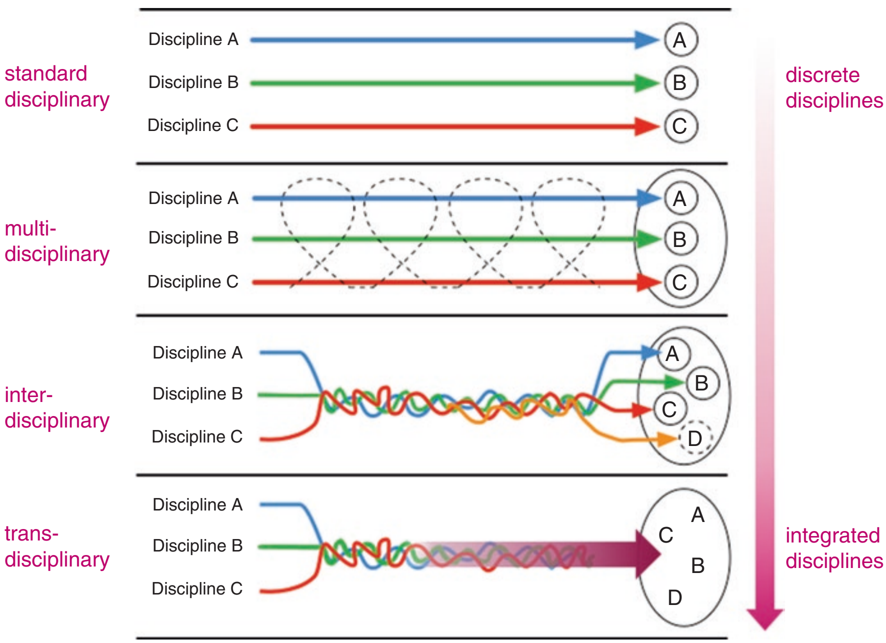

Fig. 7.1 Defining integrative approaches to teaching and learning

techniques is limited, as each student works on their own discrete component of the overall problem and submits their contribution back to the group for incorporation. In a multidisciplinary team, there is little opportunity for other group members to learn and integrate ideas. Another example of multidisciplinarity within teaching and learning is when students opt to take elective subjects or sub-majors from different disciplines which rely on the student's own ability to assimilate and synthesize knowledge across disciplines.

The *interdisciplinary approach* integrates knowledge across distinct disciplinary subjects by teaching subjects concurrently whilst also providing opportunities for the creation of new knowledge through emergent learning processes. Interdisciplinary teaching and learning therefore requires educators to have knowledge that spans several disciplines, and to be experienced in how knowledge can be shared between these disciplines. This requires a high level of specificity within and between the subjects being taught. Interdisciplinary subjects therefore tend to represent cutting edge knowledge at the intersection between two or more disciplines (e.g. a course in cyber-security would represent the disciplines of law, computer science and social/cultural studies). In Fig. 7.1 this intersection is represented by the creation of a new subject "D" which may eventually become its own unique discipline given sufficient time.

Finally, a *transdisciplinary approach* to teaching and learning transcends specificity in favour of an open, agile and problem focused context of learning. Under transdisciplinarity, subject specialization and specificity become less important. The object is to use knowledge creatively, irrespective of disciplinary background, to learn through the process of problem solving. Transdisciplinary teaching and learning works best when both students and educators come from a diversity of backgrounds and have a plurality of experience and knowledge. The range of theory, methods and practice being taught must be relevant to the context in which teaching and learning is taking place, and rated on the potential for maximizing learning through the process of problem solving. Teaching and learning in this situation does not need to be discipline- or content-specific; rather, it aims to teach a process of integrative enquiry supporting the deconstruction and then reconstruction of existing knowledge, theory and practice. This process is represented in Fig. 7.1 as the reconstruction of disciplinary expertise that is specific to the problem. Skills to support integrative inquiry have been identified (see Fam et al. 2017; Augsburg 2014) providing insight into potential skills development, but is beyond the scope of this chapter.

The underlying premise of integrative approaches to education is the concept of epistemological pluralism (Miller et al. 2008). This premise takes as its starting point an understanding that the complexity of the natural world cannot be represented by a single epistemological, theoretical, or investigative approach (Longino 2002). Restructuring academic approaches to education in ways that acknowledge and respect epistemological pluralism at the centre of the research enterprise is a step toward a more integrative understanding of complex problems. Central to the prospect of epistemological pluralism is the commitment to open and deliberate discussion and negotiation of disciplinary values and knowledge perspectives.

7.3 Planning the Introduction of Interdisciplinary Postgraduate Programmes: University of Technology Sydney (UTS) As a Case Study

Much of the significant growth in knowledge production over the past several decades has been "occurring at the interdisciplinary borderlands between established fields" (Klein 2010, p. 17). An accepted definition from Klein and Newell (1998) clarifies the practice and purpose of interdisciplinary studies as *"a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession… [It] draws on disciplinary perspectives and integrates their insights through construction of a more comprehensive perspective (pp. 393–4)"*.

In order to carry out interdisciplinary activity, one must have both disciplinary capability and interdisciplinary conversance (Hartesveldt and Giordan 2008). Traditional academic disciplines carve out particular areas of knowledge and share sets of guiding questions, concepts, theories, and methods in order to understand those features as deeply as possible. Interdisciplinary and transdisciplinary approaches ask how these disciplinary understandings can be merged, expanded, and transcended (Derrick et al. 2011). In the educational context this translates into a new kind of learning, where the challenge, problem or project-based approach treats traditional pedagogy and disciplinary expertise as a foundation. In addition to disciplinary understanding and mastery, the features of an interdisciplinary or transdisciplinary approach will often: (1) include project-based work (2) be team oriented (3) address complex problems (4) focus on the creation of new knowledge rather than the learning of existing knowledge and (5) involve collaboration with external partners and clients, whether they be businesses or public bodies (Derrick et al. 2011; Mulgan et al. 2016).

The following section describes how an Australian university (the University of Technology Sydney or UTS) planned for the introduction of interdisciplinary postgraduate degrees with 2 years of research and engagement with faculties across the university. In the process, it identified meta-considerations for planning, introducing and standardising interdisciplinary learning within UTS.

In aligning with UTS strategic plans for implementing a range of disciplinary, interdisciplinary and transdisciplinary programmes (see Fig. 7.2) the authors were commissioned to scope the potential for introducing interdisciplinary programmes at UTS with the view that approximately 20–30% of all future programmes at UTS aim to be interdisciplinary (as defined in the previous section).

The methodology adopted for determining the potential for interdisciplinary programmes at UTS consisted of three key stages: (1) a desktop literature review of best practice for interdisciplinary programmes internationally (2) consultation and engagement with senior executives and faculty leaders, and teaching and learning and operational staff to identify the perceived challenges and opportunities, and (3) synthesis and validation of research findings with senior and executive management of the university to plan the next steps in piloting interdisciplinary postgraduate degrees.

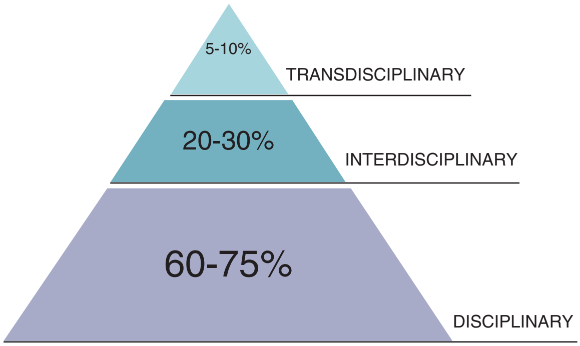

Fig. 7.2 University of Technology Sydney (UTS) plans for implementing disciplinary, interdisciplinary and transdisciplinary programmes

Desktop Literature Review on Best Practice in ID Programmes
The first phase of this project involved an in-depth review of local and international interdisciplinary programmes. Several frameworks, structures and pedagogies were identified which exemplify how interdisciplinary (and transdisciplinary) programmes have been established within universities.

Consultation and Engagement
The second phase of the project involved conducting semi-structured interviews with 27 senior academics, faculty deans, executive, administrative and teaching and learning and operations staff across the university to better understand the advantages, disadvantages, and barriers associated with introducing interdisciplinary degrees. Each interview took between 40 and 60 minutes and they were recorded and transcribed before being analyzed by the research team using a grounded theory approach to reveal seven meta-considerations for introducing interdisciplinary programmes.

Workshops
Overarching themes emerging from the analysis of interviews were presented in an interactive three-hour workshop to elicit discussion and feedback from university staff. The workshop was designed to address three key themes: (1) planning for successful governance, (2) operationalizing interdisciplinary programmes, and (3) designing flexible and innovative courses. Workshop participants were provided with a written summary and synthesis of the workshop and were invited to provide feedback and commentary on the findings. This feedback was then incorporated into the draft project report, with academic and management committees given presentations on key findings from the project.

Synthesis and Validation
The final stage of the methodology was to synthesize all data and feedback from participants for input into the final report. Key recommendations were then summarized and incorporated into the trial of two to three interdisciplinary postgraduate programmes in 2018–2019.

7.4 Seven Meta-considerations for Introducing Interdisciplinary Programmes

In addition to identifying structures/models for interdisciplinary and transdisciplinary programmes, data from the 27 interviews and four workshops with staff across the university were analyzed and synthesized to reveal seven meta-considerations for introducing interdisciplinary programmes at UTS. The seven themes are briefly described below with a sample of quotes drawn from interview data to illustrate and substantiate the themes. In addition, a representative 'word cloud' was created for each meta-consideration to visually represent key concepts discussed by interviewees under each theme (Fig. 7.3).

7.4.1 Meta-consideration 1: Create an Interdisciplinary Community and Culture

Participants believed there was a need to develop and foster supportive and mutually beneficial relationships between students and between students and faculty members. They also said there was a need to acknowledge the importance of building dynamic and healthy working relationships between faculties. These relationships were perceived as necessary for maintaining a lifelong connection. Participants also said there was a need for embedded structures to support an interdisciplinary culture and community. As one senior executive noted:

> An entity that has a common … and familiar structure for students, an entity where the staff who are teaching into it feel that there is a common goal and a common purpose … is really important. [Interdisciplinary programmes] absolutely have to fit within the structure of the university. If it doesn't now, then the university structure has got to change to [create] this entity.

Fig. 7.3 Word cloud: *Create an interdisciplinary community and culture*

Fig. 7.4 Word cloud: *Interactively engage with industry and external stakeholders*

Creating a 'cohort' experience was an overarching concern for the vast majority of participants. They believed this would require structuring interdisciplinary programmes in a way that: ensured a sense of belonging, built a network of peers, developed shared learning, and contributed to student retention. Creating a "sticky campus philosophy" by ensuring face-to-face contact needs to be effectively combined with the best of virtual and online components of teaching and learning (Fig. 7.4):

> You have to get them to cluster together and work together and that only happens with a mix…[of] face-to-face contact, but also [developing] a cohort identity.

7.4.2 Meta-consideration 2: Interactively Engage with Industry and External Stakeholders

Engaging industry and external stakeholders with interdisciplinary programmes was perceived as necessary to produce twenty-first century employment-ready graduates, and to ensure the development of integrated skillsets, both broad-based and specialized, to meet industry needs. Creating a "cradle-to-cradle" relationship with industry is required, where industry partners are involved from the inception through to completion of the interdisciplinary programmes as evaluators of programmes and student projects. This approach was also seen as a way of ensuring students gain authentic learning experiences:

> Working hand in glove with industry to solve industry problems through the [interdisciplinary] degree … makes it very authentic; it means that students really get hands on experience and different types of experience that they get nowhere else.

Interviewees noted that adaptable and innovative interdisciplinary degree programmes should ideally both partner with, and service, industry and external stakeholders, while seeking industry endorsement and buy-in for new educational

Fig. 7.5 Word cloud: *Understand external market dynamics*

programmes. This ensures the most up-to-date skillsets are developed and are aligned with industry needs (Fig. 7.5):

> I really do think that it is our responsibility to talk to industry about what the requirements of industry are now and into the future and what are the jobs of the future that don't even exist now, and how we start to help build that.

7.4.3 Meta-consideration 3: Understand External Market Dynamics

Clearly understanding 'external market dynamics', the impact of competitors on the market (i.e. university and industry offerings), and the demand for new educational programmes in current and future markets has the potential to ensure that interdisciplinary programmes are sustainable over the long term. With a declining post-graduate market, identifying relevant industry skills and market demand before investment in new programmes is undertaken is key. In addition, clarifying the scope, purpose, and added value of interdisciplinary programmes to a disciplinary degree was perceived as critical:

> From a strategic point of view the university obviously wants to keep innovating its programmes, wants to have courses which are attractive to the market, courses which are responding to employment requirements.

As domestic and international markets differ significantly, ensuring a clear focus, structure and 'storyline' of interdisciplinary degrees, and communicating this story for the target market, is needed (Fig. 7.6).

> I think when there is a lot of potential—my argument has always been that if you have got two degrees and the new one is awesome but similar, could it pass the five minute test talking to a parent… to what the difference is between one and the other. I think there needs to

Fig. 7.6 Word cloud: *Operationalize and overcome transition tensions early*

> be good consultation and I think good sound market research undertaken, not only about the name but about the type of degree before we launch into it.

7.4.4 Meta-consideration 4: Operationalize and Overcome Transition Tensions Early

Existing university structures tend to reinforce disciplinary boundaries, potentially creating tensions when transitioning to new interdisciplinary and transdisciplinary programmes. There was a perceived need for start-up funding for interdisciplinary programmes and distribution of funds across faculties. The staffing needs of these programmes, existing teaching capacity, and the need for capacity building for academics unfamiliar with interdisciplinary approaches to teaching and learning were identified as significant operational issues that would needed to be addressed:

> Finding the right people is perhaps the most challenging part of putting together these [ID] programmes. Universities tend to, or have historically focused on disciplinary specialization so most of the KPIs for academics centre around becoming experts in their discipline and […] the research evaluation frameworks tend to be structured around disciplinary classes.

Participants pointed to the need for resources such as space, funding and staff. They also believed there was a need for incentives and rewards to recruit academics into interdisciplinary programmes (Fig. 7.7):

> The funding models that support interdisciplinary programmes become quite critical as incentives [and] drivers, but it's also trying to ensure that you have the right incentives that encourage behaviours that you need, rather than behaviours which are not really ideal from the point of view of developing [integrative] curricula.

Fig. 7.7 Word cloud: *Plan for successful governance*

7.4.5 Meta-consideration 5: Plan for Successful Governance

Interviewees suggested that the successful governance of interdisciplinary programmes would require appropriate design, implementation and evaluation that should ideally be developed in collaboration with faculties across the university:

> There would have to be a greater degree of collaboration … and really joint decision-making around interdisciplinary programmes […] if we're doing something new, I think we really need to be working closely with other faculties to ensure that we do have it well set up.

The accreditation of programmes with industry buy-in to ensure relevance and longevity, and funding structures that ensure financial viability need to be considered across faculties. It will also be necessary to consider how the programme adds value to the existing suite of disciplinary programmes offered by the university.

In planning for successful governance, an effective university structure will ideally include a committee to ensure that interdisciplinary programmes proposed have inter-faculty collaboration input, and it will include investment for a senior position at the university to oversee the transition to interdisciplinary programmes. Deans from all faculties would ideally participate in sending a clear message from management about the value of these programmes and leadership at both a university and a faculty level (Fig. 7.8).

7.4.6 Meta-consideration 6: Design Courses for Innovation and Flexibility

Flexibility in options, teaching methods and subject selection will enable the university to cater to the diverse needs of both domestic and international students, and is increasingly seen as a preferred approach to teaching and learning. Flexibility is

Fig. 7.8 Word cloud: *Design courses for innovation and flexibility*

required for optimizing course structures to benefit both student outcomes and the ultimate success of interdisciplinary programmes. Flexibility in this context relates to offering a range of options to students through online study, intensives, evening courses, and industry programmes. This will require staff to teach via a range of approaches including blended, online, face-to-face and experiential and flipped learning, and the university will need to offer students core, compulsory and common subjects:

> The online learning platform I think is really important. That has to be a really strong part of interdisciplinary programmes, because if we're trying to take a hybrid approach and adopt a blended model, your online offering has to be excellent for students to think it's worthwhile.

The university will need to tailor programmes to cater for students at different career stages, students with industry experience, and students who are transferring from undergraduate courses. This will provide an opportunity for innovative learning experiences in working across a number of faculties, and is operationally more challenging (Fig. 7.9).

> The more core subjects and mandated subjects you have the easier it is to control. The less you have and the more electives you have the more tailor-made it is to the individual and, often, the more attractive it is to the student. That … can be a harder thing operationally [but a more innovative learning experience].

7.4.7 *Meta-consideration 7: Ensure Quality, Rigour and Relevance*

To ensure the success and long-term relevance of any programme, academic quality and rigour must be paramount. How academic quality and rigour is evaluated and ensured in interdisciplinary degrees was an emerging theme in the analysis.

Fig. 7.9 Word cloud: *Ensure quality, rigour and relevance*

> How do we create the threads of integration across an interdisciplinary programme, so that there is a purpose as to why we put these subjects together? That there is a relationship between the different subjects… How you structure rigour into disciplinary inquiry, as opposed to something that's undisciplined in the negative sense of that term, is actually really important.

Aligning programmes to industry standards that are assessable, that meet quality criteria, and that have a clear storyline and purpose was highlighted by participants as a key consideration. There was a perceived value in offering external audits and evaluation processes to ensure the integrity of the interdisciplinary programme meets UTS standards as well as industry standards:

> They are really going to have to make sure that the quality assurance behind new courses are there too. The curricula which students are being presented with, the quality of the teaching … You have to put quality assurance processes over things. No university would be worth its salt if they didn't put quality assurance processes over things.

Building capacity for academics to teach both within and across faculties, developing new skills, and clearly identifying necessary skillsets for students were noted in discussions on quality assurance:

> Retain people's disciplinary skills and capacities […] I think that's a really important thing … because the best interdisciplinary work comes really from an understanding of what your discipline is.

And importantly, there was recognition by participants that there isn't a 'one-size-fits-all' model for interdisciplinary programmes, and there was a recognition that the university would need to consider supporting multiple models:

> I'm coming to the belief that there isn't one model. You really have to be able to operate multiple models. There's no one size fits all because every faculty (or discipline) will have its own processes and ways of doing things … weighted to some method or way of operating.

This research has highlighted the importance of seven meta-considerations in introducing interdisciplinary degrees at UTS. Key recommendations have been to: (1) work together with senior staff to overcome the identified operational challenges of introducing interdisciplinary programmes, (2) pilot three interdisciplinary degrees using the 'meta-considerations' as a guiding framework and (3) evaluate these programmes as they are introduced and implemented.

7.5 Interdisciplinary Learning and the Research–Teaching Nexus

One recurring suggestion from the interview data we would like to expand on is the inclusion of a capstone (research) project in interdisciplinary degrees, where students are encouraged to work on 'real-world' industry-engaged research projects. There are significant advantages to offering a capstone project with collaborative industry input:

- It provides the student with an opportunity to experience how interdisciplinary knowledge might be integrated in practice when working across faculties and with industry.
- It provides industry with an opportunity to work with students on 'real-world' research, and encourages sponsorship of student-led projects and the strengthening of the university's relations with industry.
- It provides an opportunity for students to demonstrate their ability to undertake industry-engaged research and may provide them with a gateway to further postgraduate research.

The relationship between research projects and teaching and the development of explicit links between research and teaching is the subject of ongoing debate and interest in higher education (Jiang and Roberts 2011; Brew 2012; Jenkins et al. 2008). The challenge, as Boyer (1990) argues, lies not in focusing on the differences between research and teaching, but in seeking the potential synergies between these two academic activities. Moving beyond the binary classification of 'teaching' and 'research' towards the widely respected typology of scholarship developed by Boyers (1990) and Glassick et al. (1997) helps to explain the interrelatedness of scholarship. Boyer's typology consists of four core dimensions:

- ***Discovery*** (advancing knowledge)
- ***Integration*** (synthesizing knowledge)
- ***Service or engagement*** (advancing and applying knowledge)
- ***Teaching*** (advancing and applying knowledge about how to teach and promote learning).

From this nuanced perspective of scholarship, the interrelated nature of scholarly activities becomes clear, particularly when viewed from interdisciplinary approaches to teaching and learning. As defined earlier in this chapter, interdisciplinary and transdisciplinary approaches focus on the creation and integration of new knowledge rather than the learning of existing knowledge, and it involves collaboration with external partners and clients (service and engagement). With these concepts in mind, it is important to distinguish between teaching processes for interdisciplinary research, and teaching subject matter that naturally sits at the boundaries between disciplines where expertise within individual disciplinary content areas merges to form a new interdisciplinary subject (e.g. cyber-security combines elements from the disciplines of law, computer science and social/cultural studies).

Institutions that are internationally recognized for teaching quality and the employability of their graduates are also institutes where research and teaching are closely interrelated (Miller et al. 2012). Innovative and effective approaches to teaching and learning are informed and improved by research, and they contribute to shaping research issues and agendas. It is vital that students are not only exposed to the research of their tutors, but that they also engage in research practice in their own right as part of higher education pedagogy—this is the key distinction between higher education and further education. Therefore, a suggested structure for interdisciplinary programmes has been to incorporate a student-led, interdisciplinary research (capstone) project.

7.6 Conclusion

The tertiary education sector is going through a period of transition. The “chalk and talk” model that was once the backbone of university education is no longer relevant in a twenty-first century global context. Novel teaching and learning models are needed to deliver twenty-first century skills that support collaborative research, collective learning and engagement with real-world industry/government/societal problems that intrinsically cross disciplines, boundaries and knowledge perspectives. Higher degree institutions are starting to re-examine their strengths and weaknesses in an increasingly crowded educational market. They are responding to these challenges by offering integrated curricula and an array of new methods and approaches for engaging students in learning across disciplinary perspectives.

This chapter has reflected on a project scoping the potential for introducing interdisciplinary programmes across the university. The chapter presents findings from 2 years of research and engagement with senior executives and university staff and a desktop review of international best practice for implementing interdisciplinary postgraduate programmes. The results of the review revealed the success of implementing postgraduate interdisciplinary programmes was mixed, and that governance and management structures varied significantly across universities. Each of these governance structures was shown to have its own strengths and weaknesses for implementing best practice in interdisciplinary learning.

The interviews and workshops identified seven meta-considerations for successfully implementing interdisciplinary programmes, including the need to: (1) create an interdisciplinary community and culture (2) interactively engage with industry and external stakeholders (3) understand external market dynamics for targeting interdisciplinary degrees appropriately (4) operationalize and overcome transition tensions early (5) plan for successful governance (6) design courses for innovation and flexibility, and (7) ensure quality, rigour and relevance of the courses being offered.

This research has provided clear recommendations for faculties to design these programmes. There is also acknowledgment of the need for industry-engaged, collaborative research where students are supported to work on complex 'real-world' problems in their degrees (i.e. through a capstone project). Importantly, there is also greater clarity about the management and operational issues that need to be overcome for standardising interdisciplinary degrees in practice.

Interdisciplinary and transdisciplinary research and education are now associated with the provision of important economic and societal benefits, and it is widely acknowledged across the sector that integrative learning outcomes may include solutions to real-world problems. Many institutions have adopted an image of the university as a "problem solver" as they systematically engage with the complexities of societal issues. We hope the specificities and insights of this exemplar will contribute to a growing understanding of the opportunities and barriers that exist across the sector, and that the findings will feed into the efforts to support a systemic approach to the transformation of campus cultures and institution-wide change.

References

Augsburg, T. (2014). Becoming transdisciplinary: The emergence of the transdisciplinary individual. *World Futures: The Journal of New Paradigm Research, 70*(3–4), 233–247.

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. San Francisco: Jossey-Bass.

Brew, A. (2012). Teaching and research: New relationships and their implications for inquiry-based teaching and learning in higher education. *Higher Education Research and Development, 31*(1), 101–114.

Derrick, E. G., Falk-Krzesinski, H. J., & Roberts, M. R. (Eds.). (2011). *Facilitating interdisciplinary research and education: A practical guide*. Workshop report from science on FIRE: Facilitating Interdisciplinary Research and Education, American Association for the Advancement of Science, Colorado.

Fam, D. M., Smith, T., & Cordell, D. (2017). Being a transdisciplinary researcher: Skills and dispositions fostering competence in transdisciplinary research and practice. In D. Fam, J. Palmer, C. Riedy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability outcomes* (pp. 77–92). London/New York: Routledge.

Glassick, C. E., Huber, M. T., & Maeroff, G. I. (1997). *Scholarship assesses: Evaluation of the professoriate*. San Francisco: Jossey-Bass Publishers.

Golding, C. (2009). *Integrating the disciplines: Successful interdisciplinary subjects*. Report for The Centre for the Study of Higher Education, The University of Melbourne, Victoria.

Hart Research Associates. (2015). *Falling short? College learning and career success: Selected findings from online surveys of employers and college students conducted on behalf of the*

Association of American Colleges and Universities. Report prepared for the Association of American Colleges and Universities, Washington, DC.

Hartesveldt, C. V., & Giordan, J. (2008). *Impact of transformative interdisciplinary research and graduate education on academic institutions*. Workshop Report, National Science Foundation.

Henry, S. (2005). Disciplinary hegemony meets interdisciplinary ascendancy: Can interdisciplinary/integrative studies survive, and if so, how? *Issues in Integrative Studies, 12*, 1–37.

Holley, K. A. (2009). Special issue: Understanding interdisciplinary challenges and opportunities in higher education. *ASHE Higher Education Report, 35*(2), 1–131.

Jenkins, A., Healey, M., & Zetter, R. (2008). *Linking teaching and research in disciplines and departments.* Available at: http://www.edshare.soton.ac.uk/349/1/LinkingTeachingAndResearch_April07.pdf. Accessed 17 June 2017.

Jiang, F., & Roberts, P. (2011). *An investigation of the impact of research-led education on student learning*. Technical report. Available at: http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1161&context=jutlp. Accessed 17 June 2017.

Klein, J. T. (2010). *Creating interdisciplinary campus cultures: A model for strength and sustainability*. San Francisco: Wiley.

Klein, J. T. (2017). Transdisciplinarity and sustainability: Patterns of definition. In D. Fam, J. Palmer, C. Riedy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability outcomes*. London/New York: Routledge.

Klein, J. T. (2018). Learning and transdisciplinary collaboration: A conceptual vocabulary. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Klein, J., & Newell, W. (1998). Advancing interdisciplinary studies. In W. Newell (Ed.), *Interdisciplinarity: Essays from the literature*. New York: College Board.

Longino, H. E. (2002). *The fate of knowledge*. Princeton: Princeton University Press.

Miller, T. R., Baird, T. D., Littlefield, C. M., Kofinas, G., Chapin, F., III, & Redman, C. L. (2008). Epistemological pluralism: Reorganizing interdisciplinary research. *Ecology and Society, 13*(2), 46.

Miller, A., Sharp, J., & Strong, J. (2012). W*hat is research-led teaching? Multi-disciplinary perspectives* REST/GuildHE. Available at: http://collections.crest.ac.uk/5215/. Accessed 17 June 2017.

Minnich, E. (1995). *Liberal learning and the arts of connection for the new academy*. Washington, DC: Association of American Colleges and Universities.

Mulgan, G., Townsley, O., & Price, A. (2016). *The challenge-driven university: How real-life problems can fuel learning*. Draft report, National Endowment for Science, Technology and the Arts (UK) (NESTA).

Schneider, C. G., & Shoenberg, R. (1998). *Contemporary understandings of liberal education*. Washington, DC: Association of American Colleges and Universities.

Tress, B., Tress, G., & Fry, G. (2005). Defining concepts and the process of knowledge production in integrative research. In B. Tress, G. Tress, G. Fry, & P. Opdam (Eds.), *From landscape research to landscape planning: Aspects of integration, education and application*. Dordrecht: Wageningen University Press.

Chapter 8
Transdisciplinarity: Towards an Epistemology of What Matters

Kate Maguire

8.1 Context: Transdisciplinarity and Mattering

In Europe, the separation of knowledge into discipline islands became more pronounced in the eighteenth century. Burke (2016) refers to this period as the location of the shift from 'knowing why' to 'knowing how'. He qualifies this with '*what is considered worth knowing varies a good deal according to place time and social group.*' What is worth knowing is what the anthropologist Catherine Hasse (2015) refers to as *what matters,* and for Barad (2003, p. 827) mattering cannot be separated from agency:

> Agency is not an attribute whatsoever – it is "doing"/"being" in its intra-activity. Agency is the enactment of iterative changes to particular practices through the dynamics of intra-activity…Particular possibilities for acting exist at every moment, intervene in the world's becoming, to context and rework what matters and what is excluded from mattering.

In 1995 Middlesex University in London was still completing its transition to the status of a university by gathering vocational arts and technical colleges in North London together into one entity, but spread over several campuses. Technical colleges had taught students from a wide range of backgrounds, not least those with practical skills and leanings towards 'knowing how', that is, knowledge gained from practice and for practice. This did not exclude theoretical knowledge, which had been and still is the main preserve of universities. The Institute for Work Based Learning in Middlesex University emerged out of this transition without full capitulation to the 'knowing why' dimensions of the intellectual paradigm. Rather, it began to develop a strong dialogue between the knowledges of the academy and the practice knowledges of the work world, seeking a marriage that would produce offspring to meet the growing technological sophistication and complexities of the

K. Maguire (✉)
Middlesex University, London, UK
e-mail: k.maguire@mdx.ac.uk

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_8

new world. The timing was right. The university became the recipient of the Queen's Anniversary Prize three times; the Queen's Award for Enterprise twice; the Higher Education Academy's Centre for Excellence award and a major funding award to advance work-based learning and professional studies across the university and in outside partnerships. These were in recognition of its attention to higher education's role in what matters to communities and what matters for the future for the widest number of stakeholders. This could not be achieved without the reintegration of academic and professional knowledges.

In this new arena of working partnerships with professional bodies and work worlds outside of the university, the Institute explored new conceptualizations of practice, and new methodologies, pedagogies and ways of learning; it re-contextualized existing ideas from a range of discourses; it challenged the exclusion of experiential learning from the entry criteria for higher awards by pioneering accreditation for prior professional learning; and it contributed significantly to the existing literature on the vocational sector. This literature emerged primarily from Australia and the United States. Much later, Europe's Horizon 2020 would embody this value-driven approach by making available millions of Euros in funding for projects to entice higher education institutes to work with local organizations, from football clubs to local councils, to regenerate communities in what we might call today transdisciplinary ways. This involves working together across difference; openness to listening to the perspectives of the other; consensus rather than compromise; and the dialogue of knowledges from street cleaner to CEO, to arrive at what the particularity of local culture needs in order to thrive for the benefit of the individual and the collective in a world of complexity.

After the establishment of its 4-year doctoral programme, it turned its attention to the need to deep mine the professional expertise and knowledge of recognized leaders in the professional arena who, through a range of significant artefacts, were influencing thinking and practice with a reach far greater than the academy could achieve. However these artefacts, on the whole, embodied the knowledge of individuals or small groups of individuals and had rarely been subjected to critique by their creators. As a consequence it introduced the Public Works doctoral pathway, the nearest equivalent being the PhD by publication. This programme now has over 30 graduates.

The Institute has over 200 doctoral alumni from a range of sectors and disciplines, 120 current doctoral candidates, and scores of undergraduates and master's candidates from major international organizations. The Institute's leadership in collaborative pedagogy, curriculum and research, the integration and enhancement of academic (single discipline) and professional knowledge (multidiscipline) was recognized in 2017 in the university's new strategic plan. The Institute's expertise and programmes have now been integrated into the main university with a mandate to continue this approach to knowledge for the future as the university further aligns to the complexities of interconnected work worlds.

In 2013, the Institute had added to the title of its highest award, the descriptor *Transdisciplinary*. This chapter explores why it did so. The explanation is informed by the evaluation and outcomes of its programmes; the master's and doctoral output of its graduates; the contribution to knowledge of its staff and alumni; and a recognition of the complexities of practice. Most importantly, a key motivation for adding the new descriptor was the rapidly shifting work environments which were challenging higher education's capacities to keep up with the demands of business-led markets without compromising on its wider interpretation of education as inclusive of the arts and humanities, of soft skills like the capacity to relate and reflect, and the value sets which attend to the 'common good'. These are the humanizing factors that focus on ways of being in the world as well as ways of doing and challenging the pervasive epistemology of ignorance (Malewski and Jaramillo 2011) which endangers the quest for a more equitable and sustainable future. It can be argued that, like anthropology, transdisciplinarity is more than the knowing why and the knowing how; it is a way of knowing; it is the developing of an attitude to the world which is a contribution to an epistemology of what matters locally and globally.

To arrive at an epistemology related to interconnectedness and complexity would also require a world-view that embraced complexity, in other words an ontology of complexity (Boulton et al. 2015). It was clear to the doctoral team that proficient practitioners coming into the programme already held an ontological position or world-view derived from their work worlds, that of interconnectedness and complexity; it was a defining feature of their reality. It was more surprising to them that universities on the whole did not have such a perspective. Our approach to programme design focused on this ontology embedded in practitioners. Our task was to help them articulate the beliefs, meanings and actions which shape that view through exposure to diverse discourses, and to explore with them ways of bringing about change through this understanding of 'how the world becomes' (Boulton et al. 2015: 11). Transdisciplinarity, as will be seen, provides an articulation of the ontology of complexity and offers contributions to a framework, an epistemology, for constantly engaging in ways of knowing and shaping the world in which we live and work. According to Nicolescu (2010, p. 22)

> Transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all disciplines. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge.

8.2 Research Approach

According to Terry Eagleton (2004, p. 208), "because our life is a project rather than a series of present moments, we can never achieve the stable identity of a mosquito or a pitchfork". Like Eagleton's view on life, our research pedagogy sees research as a project, an evolving thing that requires, not a closing or finishing, but a built-in adaptive capacity for evolving. For example, the case study intentionally breaks its confines and seeks generalizability through examining other case studies or through extracting what can be applied successfully across more than the case study locus; or the case study becomes a constantly revisited locus in a longitudinal study; or a case study can be a study of the interconnectedness of things, a topic which does not have a traditional locus and therefore avoids the discipline- and culture-bound paradigms which can suffer from replication syndrome. Evolving comes with a past, a present and a future, but it is neither linear nor determined. Research needs to be more generative than replicative or it will end up like Koestler's fear for humans: a dead-end species (1978). Boulton et al. (2015, p. 103), in their call for us to embrace complexity, refer to the same characteristics.

> Evolutionary complexity accepts the fact that 'systems' can change their nature qualitatively over time. New elements, new interactions, new problems and new opportunities can appear without design, and indeed these evolving systems will actually co-evolve with each other so that the overall system is really discovering/creating itself over time and responding adaptively, leading to further co-evolutions.

Choosing this transdisciplinary approach for our programme reflects our belief in the need to shift away from traditional approaches, but as a complementary rather than an opposing action. This approach also resonated with changes in our nomenclature which had started with our foundations in work-based learning. A doctoral thesis becomes a research project; the proposal becomes a plan; the research questions become a conceptualization of the issues; the outcome becomes the impact; the assessment criteria relating to methodology become the methods most appropriate to achieving the data sets that will enhance the reliability and the impact; the ethics of research become the personal and professional integrity of the researchers.

The focus of a PhD can be seen as the equivalent of mining an island. The locus of the mining will involve using the apparatus appropriate to the geological terrain of the island. It will consistently produce a reliable standard of the product that particular terrain has to offer and over time more complex 'things' evolve and are sent out to be of use, to be applied in different ways in different contexts. These products range from atomic bombs to mapping the brain; from social theory to new political movements. Professional doctorates do not have the same loci. They are positioned along the three-dimensional in-between connectors of islands, carrying cargo, using apparatus conducive to the changing climatic conditions and open to researching both the connector itself (shipping lanes) and its role in cross-pollination between islands (practice) which evolves the knowledge, experiences and products of those islands and creates ever increasing archipelagos. This is at the core of transdisciplinarity: the interconnectedness of things, like the synapses of the brain, and how this can be harnessed and expand to release potential for the future without incurring a psychotic breakdown.

The 'research project' can only ever be a thread in this 'metissage'[1] but its impact can be significant and it can contribute beyond itself to the evolving complexity of the research context. The research project is expected to be collaborative, as the practitioner in the work world is never confined to a single discipline and never operates alone. The researcher/practitioner has to know about, but not necessarily be, a deep miner in a range of disciplines in order to navigate the connectors successfully and achieve outcomes which matter to the individuals, to the organiza-

[1] French: a weave, like a tapestry (Nouss 2005).

tions, to the communities they connect, and to the existing knowledge landscape. This is because interconnectedness makes it an imperative to be both highly adaptive and contributory to local context and global influences: the wings of the butterfly; the drop of rain; the shooting of an individual in a street; $50 dollars on a stock market gamble; the power of the local to influence the global.

8.3 Agency and Story

> It is the very fact that we cannot live in the present – that the present for us is always part of an unfinished project which converts our lives from chronicles to narratives. (Eagleton 2004, p. 209)

This shift to researching practice and theorizing practice has given rise to one of the most common criticisms of professional doctorates, that is, the use of the first person and not the objective/passive voice. This dictatorship of grammar and syntax (the active and passive, the subjective and objective) to signify what is reliable and what is not in research is a convenient and superficial way to differentiate between what should be acted upon and what should not (Eastman and Maguire 2016). Practice is about the agency of the practitioners in an interactive relationship with the 'objects' of their world, including other humans and learning and evolving from those interactions. The use of the passive, and claims to objectivity, can be an abnegation of responsibility and accountability, as much as it can be argued as an indicator of reliability through consistency. The agency of 'I' in terms of impact has informed not only thinking but action in what matters to the lives of everyday people: prejudice; marginalization; exclusion; vulnerability; identity; financial security; safety and belonging needs; a future for their children; facilities for thriving.

As metrics take over the 'managing' of complexity, the narrative comes into play to explore and explain what sits behind the metrics and prevents their exploitation by those who seek to control the agendas, including those of higher education. If higher education was to be likened to an egg in the process of becoming a butterfly, its current metaphoric and metamorphic state would be a chrysalis, trying to evolve beyond restrictions while vulnerable to being genetically engineered to fly in one direction and communicate with those with whom it is programmed to communicate, and how, rather than as an informed pollinating agent with a value system that aims to do what is needed through collaboration, and a mandate to attend to what matters to people and to the planet. Some of the most influential thinkers of the twentieth century used their individual agency, the 'I' or sometimes the 'we', to present their critical observations and understandings of what it is to be human, rather than the product of a discipline: Pierre Bourdieu, Mark Twain, Barbara Ehrenreich, Albert Einstein, Edward Said, Margaret Mead, Mario Vargas Llosa, Arthur Koestler, Slavoj Zizek, Antonio Gramsci, to name a few. Their impact remains generative over time, perhaps because it did not emerge from a replicative system. They dare to declare their own agency and are accountable for it.

They have observed, experienced, conceptualized, contextualized, questioned, thought, compared and acted in and on the world in their unique ways. What links these diverse writers together in a knowledge community is their common humanity. They do not manage complexity; they create ways to both navigate and contribute to it. They do not fear it, only the possibility that we will be irretrievably shipwrecked, a fate which could take many forms, from catastrophic damage to the planet to that of the mind, our humanity.

> We would be worse than we are without the good books we have read, more conformist, not as restless, more submissive, and the critical spirit, the engine of progress, would not even exist. Like writing, reading is a protest against the insufficiencies of life. When we look in fiction for what is missing in life, we are saying, with no need to say it or even to know it that life as it is does not satisfy our thirst for the absolute – the foundation of the human condition – and should be better. We invent fictions in order to live somehow the many lives we would like to lead when we barely have one at our disposal. (Llosa 2010)

8.4 Narratives of Complexity

Complexity is now seen as one of the greatest challenges to successful research, yet it is not always part of the preparation of a researcher. For many, complexity is accompanied by some reference to technology and the speed of change. For some, technology is the creator of complexity. However, Augé, the French anthropologist, has a more nuanced and valuable perspective (1999, p. 53):

> We are just learning to imagine the complex past of a planet that until recently had never been grasped in its entirety by a single point of view (even today we would be hard put to find a specialist capable of drawing a single picture of the world during the period when Athens and Sparta alternatively dominated the Greek scene). If we are conscious of the fact that *in and of itself* technological sophistication tends to play a simplifying role – to have an homogenizing effect – we should logically conclude that complexity *precedes* the instruments susceptible of apprehending it and making it manifest.

Therefore, at the end of this particular part of the evolutionary path for our candidates, we are not looking for a report or a thesis but a knowledge narrative. It is a story of searches and of relationships, of choices and integrity, of honesty and accountability, of creativity and daring, of revealing and decontextualizing. It is a narrative of collaboration and pollination. The research does not begin at the point of entry to the programme; it started many years before that. The professional doctorate facilitates an articulation of what is already implicitly known; it weaves the why with the how and sets the candidate on the road again with new insights, contributing to a process of becoming, not one of arrival. The researcher brings a story of context to the table; their relationship to that part of the knowledge landscape with which they have grown familiar, in fact, in which they may be considered an expert; they come with a willingness to critique the limitations of their terrain and motivated to explore others; they usually carry with or in them a set of values, a code of conduct which can inform their whole project, acting as a barometer for every decision they make from choice of methodology, to participation, to intention. Why would the academy not bring the same to the table?

8.5 Knowing Matters

> A man was on a boat in the middle of the ocean that looked like the middle of nowhere. The boat was going round and round making no progress. The man looked up at the stars and knew they had a message for him. But he no longer knew how to read them. (Maguire 2004)

We cannot yet say we do transdisciplinary research in the form carried out by, for example, climatologists, town planners and Horizon 2020 community projects. We are still in the process of clarifying how this transdisciplinary discourse can facilitate the meeting of knowledges to achieve more salient outcomes. At this stage, unlike Nicolescu, we may be seeking, not the unity of knowledge, but the coherence of knowledges. For a start, the academy and the work world have different relationships to temporality. The work world is an environment which changes from day to day. It has to respond faster, be more adaptive, think outside the box, and de-activate memory retrieval to divert energy to the insatiable appetite of the present future. It is a place, after all, where the future has already arrived. The academy, on the other hand, dwells between the past and an *out of focus* present. Its memory retrieval is excellent—perhaps it needs to work harder on decontextualizing memories as knowledge for the future. Its tempo is slower, which is not necessarily a negative condition. It has many advantages but the academy, in seeking to be a worthy supplier of goods and services to the work world, can become preoccupied with developing instruments to enhance its value to the outside world which strip it of the very asset that is most valued by the work world: the ability to think, to reflect, to learn, to question the what, the why and the how of actions and the consequences of impact.

We can work with senior professional practitioners on how to make sense of the academic discourses for a practical work world. This is a step often overlooked. We currently use transdisciplinarity in our programmes for three main purposes: (1) In the development of a way of being in the world which involves: collaboration; social mindedness; coherence across difference*; being with other* rather than *being the other;* common values of humanity; dialogue; benefits to the widest number of stakeholders; and openness to being changed by one's own experience and the experiences of other. (2) As a way to conceptualize complex practice, thereby beginning the process of articulation of that which is implicit, pushing beyond the expert's response to the question, *How did you know to do that?* as *I just knew*; and (3) most importantly we use transdisciplinarity as a creative process of imaging and imagining, of transformation through removing the obstacles to one's own knowledge, of being free to think outside the confines of accepted cultural memes.

To those who ask what differentiates a transdisciplinary professional doctorate from one which is within a specialist area, the focus of a transdisciplinary doctorate is on the complexities of practice rather than on a discipline or sector. It theorizes practice, not pre-existing theory of disciplines. This theorizing of practice can contribute to how we transform educators into community activists, engineers into politicians, health professionals into negotiators. It contributes to knowledge which emerges out of practice. Its discourses are practice (Nicolini 2013) and complexity (Boulton et al. 2015). Its research sites are always the work world. The national and international criteria of assessment for PhDs and professional doctorates are the same. They are arrived at by slightly different routes; the difference is one of emphasis. They both have to tell a comprehensive, convincing, trustworthy and cohesive research story with rationales for their choices. One might arrive at the destination by road, the other by sea. They both arrive, but the knowledge narratives will not be the same; hopefully they will have complementary elements.

8.6 Critical Reflection As Movement Beyond Stasis

Perhaps one of the most distinctive differences between these doctoral routes is the impact on the researcher. Critical reflection on one's own ontological and epistemological position, and on one's own practice and current ways of doing and thinking, comes to be a criterion for judging the reliability of the research. In the professional doctorate, reliability is based not only on the common criteria of rigor but on the trustworthiness of the researcher as being capable of researching self rather than as being able to follow the paradigm apparatus. This is why personal and professional integrity are explored. This is the beginning of a thought process that moves towards a consciousness of a way of being as well as a way of doing in the world which is, as stated before, always a process of becoming. Consciousness; articulation of the implicit; freedom to explore other discourses; being creative and achieving a personal and professional impact, are regularly cited in candidate and examiner evaluations and in the research narratives themselves.

We have not achieved mastery of transdisciplinarity in the doctoral arena; we are a work in progress but would never wish to be static in our thinking. When I say 'we', I refer to the candidates, the graduates, the collaborators and the partners who have been going through a process of coming to know each other and working together in a way that not one group or individual can achieve on their own. The university has adapted processes to allow us to respond effectively and speedily to the needs of the work world. We work on collaborative programme design at the undergraduate, masters and doctoral levels with nationally and internationally recognized organizations that can demonstrate the impact of what we do together in terms of both increased profitability and relational leadership, individual and distributed leadership and social responsibility. We all enhance our performativity and performance through insight into how we learn individually and collectively through each other, for purposes beyond the limitations of the expectations we impose on ourselves (Barad 2003, p. 802).

> The move towards performative alternatives to representationism shifts the focus from questions of correspondence between descriptions and reality e.g. (do they mirror nature or culture?) to matters of practices/doings/actions. I would argue that these approaches also bring to the forefront important questions of ontology, materiality and agency.

So why should the academy seek to go beyond the limitation of the imposed expectations of the status quo, and why should it not be satisfied with a hysteresis that is such a long time lag that the field conditions have changed dramatically by the time we think we are ready? Evolution requires adaptation, and technology has increased the dissemination of information. What matters changes over time. Those practices and belief systems, which support stasis as what matters, die out, often in a spectacular manner, a manner which often negatively impacts lives, takes lives even, before their demise. According to Eagleton, it could be due to the fear of non-being, a terror of *vacancy and what they plug it with is dogma* (2004, p. 208). It is the fear of uncertainty. Observations of millions of years of evolution lead to the conclusion that human beings are not programmed to change; they are programmed to adapt, making them the most successful, voracious, colonizing, imaginative, constructive and destructive species on the planet. Afflicted with consciousness and conscience which may temper excess, they struggle with identity and meaning, with fairness, with individual and collective imperatives of territorial claims in space, time and being. The human species strives for ownership, even of that which does not exist after corporeal death. We strive for ownership of resources, including human minds. These minds dictate what matters now, but can we shape what will come to matter in the future?

Higher education contributes to the expansion of ownership through the preparedness of its recruits. However, what if what matters is a stake in the future, a good attempt to avoid annihilation? What if what matters is also about reducing the collateral losses of territorial imperatives and aspiring to the attainment of an equilibrium that is echoed in Bruno Bettelheim's words—"the informed heart" (1991). Transdisciplinarity is not a dogma; it is not a stuffing of a gap out of fear of uncertainty. It is the opening up of the creative possibilities of uncertainty in each individual; a positive uncertainty of their hitherto certainty so that they can begin to interact and connect knowledges.

8.7 Evolving Thinking

Transdisciplinarity is not a new concept. It is a product of evolution with recovered traits or new characteristics appropriate to the times. It appears when needed, which is the story of evolution; we are not looking to sprout wings. We are individually and collectively manifesting the verbal and value equivalent of wings: the common good, social justice, equality, democracy, plurality. Such wings have echoes of the ancient Greeks, the fingerprints of renaissance polymaths like Michelangelo and Leonardo da Vinci, the voices of twentieth century anthropologists and the socio-political vision of adult educationalists like Paulo Freire and Antonio Gramsci. There are more than glimpses of them in work-based learning (Gibbs and Costley 2006; Costley and Armsby 2007) which encompasses the foundational principles of the Institute. They have emerged again in the discourses of transdisciplinarity (Gibbs 2017) as a response to colliding cultures which can no longer avoid proximity, or what some might call contagion. If *culture is a systematic acquisition of human experience* (Freire 2013, p. 45) then, if we are moving towards a world culture, what are the desired values which will provide cohesion without enforced homogeneity, progress without marginalization, plurality without chaos?

For the moment, in the context of one higher education institute which I can speak about, transdisciplinarity, as a characteristic of our research, declares a particular attitude to knowledge and to the other; an intention towards particular kinds of action, action that is arrived at through cooperation; impact which attends to the common good and inclusion through the plurality voices. Just as *wisdom* cannot be self -ascribed but is bestowed by others who have recognized it in a person, so *transformative* cannot be ascribed by the people who design and deliver our doctorate with its transdisciplinary characteristics; it is ascribed to the programme by many of those who have undertaken it. What exactly transformation is, and how it occurs for the researcher practitioner, remains elusive. We can try to pin it down like the butterfly on the entomologist's tray and teach it, but that may possibly ensure its instrumentalization and atrophy, perhaps because it is not solely something that one does; it is something that one experiences. It is what we do with our experiences that matters.

8.8 Towards an Epistemology of What Matters

Taking a transdisciplinary approach does not mean, as some critics may claim, that there is no theory required. On the contrary, there are many theories and conceptualizations of practice to draw on in order to conceptualize the cultural ecology which is the location of the research and the practices within it, including those of the practitioner researcher. This conceptualization identifies not only the focus of the research but the internal and external influences that need to be taken into account when designing it. The knowledge landscape exploration will include existing knowledge on theorizing practice. The aim is not to prove or disprove a theory of practice or to create a new one. The aim is to find out how to bring about change in a complex environment that is subject to strong internal and external factors, including time, using ethically and methodologically sound processes and procedures. The theorizing of one's own practice usually occurs after the data have been collected. This is when the practitioner researcher has both substantial data and their own agential experience to consider and to interpret against existing knowledge. Based on this data and their own experience, they can draw learning for themselves, their sector and for the wider field of knowledge. Theorizing requires an understanding of epistemologies and discourses, and the recognition of one's ontological position.

The addition of the word transdisciplinarity to our doctoral title was to indicate the approach to knowledge that can be expected; it is a focus on practice which presupposes that practice is that which involves the practitioner in interacting with and across many other practice cultures. Practices have purposes which influence behaviors: some practices can be manifestations of compliance, others are manifestations of a cultural ecology seeking connections to other cultural ecologies as a means to thrive through increasing its capacity to adapt to shifting contexts and inter-contextual dynamics. This seeking is predicated on what matters in the particular context, what matters in the inter/regional context, what matters in the global context, and the interrelatedness of these for the small and the big. Practices and changes to practices could be designed to bring about radical change; others are designed to maintain the status quo. At its best, transdisciplinarity is an approach which is dialogic, consultative, realistic, values driven, context sensitive, open, enquiring and patient.

Ontology in the transdisciplinary context can be seen as an *'ontology of connectivity'* (Boulton et al. 2015, p. 204). Epistemology is about the way we know or understand the world. It is a collection of ways of knowing. Ontology and epistemology become intricately connected, constantly informing each other in an improvised dance of skill and creativity unrestricted by rigid paradigms and open to being shaped by, and to shaping, the particular and the global environments in which they move. Transdisciplinarity, therefore, can be seen as an approach to ways of knowing about what matters. It is agential. It is not embodied knowledge tied to doings and it is not learning information as lexical knowledge, which is assumed to be static and transferable. "In a practice- based learning perspective, knowledge of cultural markers is neither a substance, an object or positioned in the minds of the individual. Knowledge does not exist separately from subjects" (Hasse 2015, p. 161). For Hasse (2015) and Barad (2003), their deep focus is on how matter comes to matter. How materials are in a sense mattered.

> If the craft of expert ethnographers is how to include good descriptions of how material matters and gains significance, our own descriptions of how mattering matters must also explain how matter comes to matter to us as researcher. (Hasse 2015, p. 13)

To the practitioner researcher, what matters encompasses the individual, the local ecology and the wider context in which that ecology sits and to whose influences it has to respond. Transdisciplinarity offers a conceptual framework and an approach to research which begins to provide the conditions to understand how we come to know and to choose what matters at an individual and collective level.

Hasse (2015), inspired by Barad, gives some articulation to the agential role of the researcher. She sees Barad's apparatus of the researcher as a metaphor and proposes that the apparatus (the researcher) is an apparatus of *diffraction*

> moving into the bigger apparatus of already established phenomena emerging with words and meaningful materials. The apparatus of the researcher makes a diffracted reading of the ways matter come to matter to the people already nested in their everyday practised place. (2015, p. 15)

A diffracted view is also the lens of disruption as it begins to reveal the out-of-date rituals which are still believed and held onto, preventing the ecology from evolving. For Nicolini (2013, p. 9) there is no one practice theory, as

> practice theories are fundamentally ontological projects in the sense that they attempt to provide a new vocabulary to describe the world.

By using this new vocabulary we can, in facilitating doctoral research, offer articulations to professional practitioners of approaches to their research which do not seek to explore every 'matter' that is local, and to attend to the maintenance of the system by fixing that which may not really matter at all. Rather, our programme seeks to encourage researchers to explore the system (and themselves as part of the system) in order to locate the things which restrict the evolution of systems, and therefore their own evolution.

> Local practice thus becomes a convenient starting point and a building block for explaining not only the local production of organized action and interaction, but also, the larger, more complex trans-local phenomena, such as the existence and functioning (the organization) of a ward, a hospital, or a health authority, without contradicting the fundamental notion that practice is an oriented and concerned matter'. (Nicolini 2013, pp. 236–237)

At some point, as we continue to evolve thinking beyond disciplines, transdisciplinarity itself is likely to undergo a change in its nomenclature as it still holds within it the word discipline. What matters is that the core guiding principles will remain, because they are universal and because the approach is more about an attitude to knowledge than it is about knowledge; it is becoming as well as doing and being; it is generative not replicative; inclusive; plural and hopeful. What it comes to be called will be a matter that may not matter.

Higher education in the United Kingdom today finds itself in a storm of conflicting policies, ideologies, purposes and means. It is taking diverse and sometimes contradictory and immature approaches to organizations external to itself to forge alliances, partnerships and collaborations. It is imperative that it continues to find new and renewed sources of funding. External organizations are indeed a potential source of funding but most importantly they are a source of knowledge; they are seeking, among other things, new ideas, more relevant change initiatives and the continual development of their practitioners to augment human and cultural capital. This cannot be achieved solely by an increase in training and coaching. These practitioners live and work in complexity, which is the antithesis of silos. They thrive on internal and external connectivity and high levels of adaptive capacity. This is what we have been engaged with at Middlesex University, a process of translation between difference through our transdisciplinary *Doctor of Professional Studies* and *Doctor of Professional Studies by Public Works* programmes. Transdisciplinarity is the beginning of creating Gadamer's conditions for understanding between difference (2013). The quality of the dialogue between professional and academic knowledges and cultures could also be improved by the academy undertaking a transdisciplinary approach to itself, to its own ontology and epistemology, thereby providing a framework for organizing and acting on the values it claims to hold and facilitating a contribution to the future which lets go of the arrogance of a pre-figurative vision of that to which the majority of its members have not been invited. However, with more daring, it can help to shape the perspectives those who have.

> an African prophet–healer, a group of architects working together on a development project, or a medical team trying to figure out how to intervene in this or that social or cultural milieu all constitute realities of the same nature. Adapting to changes in scale does not mean ceasing to privilege observations of small units, but rather taking into account the worlds that cross through them, overflow them, and in so doing, continuously constitute and reconstitute them. (Augé 1999, p. 125)

References

Augé, M. (1999). An anthropology for contemporaneous worlds (*Mestizo Spaces*, A. Jacobs, Trans.). Standford: Stanford University Press.

Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs: Journal of Women in Culture and Society, 28*(3), 801–831.

Bettelheim, B. (1991). *The informed heart*. London: Penguin Books.

Boulton, J., Allen, P., & Bowman, C. (2015). *Embracing complexity: Strategic perspectives for an age of turbulence*. London: Oxford University Press.

Burke, P. (2016). *What is the history of knowledge?* New York: Wiley.

Costley, C., & Armsby, P. (2007). Research influences on a professional doctorate. *Research in Post-Compulsory Education, 12*(3), 343–355.

Eagleton, T. (2004). *After theory*. London: Penguin Books.

Eastman, C., & Maguire, K. (2016). Critical autobiography in the professional doctorate: Improving students' writing through the device of literature. *Studies in Continuing Education, 38*(3), 355.

Freire, P. (2013). *Education for critical consciousness*. London: Bloomsbury Academic.

Gadamer, H.-G. (2013). *Truth and method*. London: Bloomsbury Academic.

Gibbs, P. (2017). *Transdisciplinary professional learning and practice*. Dordrecht: Springer ISBN:3319561847.

Gibbs, P., & Costley, C. (2006). An ethics of community and care for practitioner researchers. *International Journal of Research & Method in Education, 29*(2), 239–249.

Hasse, C. (2015). *An anthropology of learning: On nested frictions in cultural ecologies*. London: Springer.

Koestler, A. (1978). *Janus: A summing up*. New York: Random House.

Llosa, M. V. (2010). *In praise of reading and fiction*. Mario Vargas Llosa- Nobel Stockholm, Lecture Dec 7. https://www.nobelprize.org/nobel_prizes/literature/laureates/2010/vargas_llosa-lecture_en.html.

Maguire, K. (2004). *Opening remark of a specialized guide to psychotherapy*. London: EACS.

Malewski, E., & Jaramillo, N. (Eds.). (2011). *Epistemologies of ignorance in education*. Charlotte: Information Age Publishing, Inc.

Nicolescu, B. (2010). Methodology of transdisciplinarity – Levels of reality, logic of the included middle and complexity. *Transdisciplinary Journal of Engineering & Science, 1*(1), 19–38.

Nicolini, D. (2013). *Practice theory, work and organization: An introduction*. Oxford: Oxford University Press.

Nouss, A. (2005). *Plaidoyer pour un monde metis*. Paris: Textuel.

Chapter 9
Transdisciplinarity and the 'Living Lab Model': Food Waste Management As a Site for Collaborative Learning

Alexandra Crosby, Dena Fam, and Abby Mellick Lopes

9.1 Introduction

Transdisciplinary (TD) research is an increasingly recognized theoretical framework for addressing complex, socio-environmental problems involving multiple disciplines and a diversity of societal actors in complex projects. The underlying assumption is that creating effective solutions to complex problems requires exchanging knowledge and experiences among a diversity of disciplines with stakeholders in both public and private spheres (Gibbons et al. 1994; Lang et al. 2012; Neuhauser and Pohl 2014; Westberg and Polk 2015; Robinson 2008; Fam and Crosby 2017). By bringing a variety of different knowledge perspectives to bear, it is assumed that there is a better chance of understanding a problem from the perspectives of those implicated, generating innovation and solutions to complex societal problems (Bammer 2013).

In the higher education context, on-campus Living Labs are one way to create an environment that supports TD research. Living Labs bring members of the public, business, government and researchers together to co-create services, systems, technologies and societal solutions. While the Living Lab concept has a range of applications, in this chapter we adopt a model that utilises the built environment of the university campus as a clearly defined educational context for bringing together

A. Crosby (✉)
Faculty of Design, Architecture and Building, University of Technology Sydney, Sydney, NSW, Australia
e-mail: Alexandra.Crosby@uts.edu.au

D. Fam
Institute for Sustainable Futures, University of Technology Sydney, Ultimo, NSW, Australia

A. Mellick Lopes
School of Humanities and Communication Arts, Western Sydney University, Parramatta, NSW, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_9

students, academics, industry experts and campus facilities management in a transdisciplinary form of collaboration.

This chapter draws on 2 years of experience by the authors in developing a 'Transdisciplinary Living Lab' (TDLL) at the University of Technology Sydney (UTS), where the on-campus food waste management system was used as the context for transdisciplinary learning by third year design students (Fashion and Textiles, Visual Communication, and Product Design). The TDLL model drew on the concept of an 'ideal transdisciplinary process' (Jahn et al. 2012) to structure skills development around three main phases: (1) joint problem formulation, (2) co-production and integration of knowledge and (3) the implementation and assessment of societal and scientific outcomes from the TDLL. Students were expected to build on skills in critical listening, thinking and reflective practice developed throughout their design degrees, as well as competencies in observation and system mapping. While systems thinking is a well-used method and tool in transdisciplinary research and practice, it is not currently a core component of the design programme at UTS. Our approach in the TDLL was to integrate critical skills for TD research, including collaboration, communication and knowledge integration (Fam and Crosby 2017) with design-specific competencies to generate a system-sensitive design curriculum. While this research is specific to design education, a similar approach could be adopted in other faculties to facilitate student understanding of systems dynamics, and to build on the skills already core to their disciplines.

9.2 The Living Lab Model

A Living Lab can be defined as an iterative learning process, operating in an institutionally or geographically bounded context, adopting a co-creation or co-design approach by integrating research and innovation experiments into real life community settings. A key characteristic of Living Labs, as with other transdisciplinary approaches to research and practice, is that a broad range of community and industry stakeholders, including everyday users, actively participate in the innovation process. The concept of the Living Lab was first developed by the Massachusetts Institute of Technology (MIT) as a way of *'bringing together interdisciplinary experts to develop, deploy, and test—in actual living environments— new technologies and strategies for design that respond to this changing world'*. More recently, the European Network of Living Labs (ENoLL) has played a leadership role in the Living Labs network globally.

Living Labs often involve longitudinal research on the interactions of users with the technology or system under investigation, resulting in collaborative learning and the co-design of solutions. When situated within a university context, with students acting as both researchers and users of the system, the Living Lab has the potential to function not only as a site for investigating current professional practices, but also as an incubator of new social practices (noted by Scott and Bakker 2012). This identification of students as both researchers and users situates them within a broader community context and values their expert, site-specific knowledge of the situation (Hummels 2011).

Campus-based Living Labs are valuable to universities and industry for multiple reasons. They build on the university's cultural role as an institution with a mandate to nurture the 'seeds of change' (Geels 2002), and as research enterprises they have a capacity to absorb the risk of innovation for industry and community stakeholders (Allen et al. 2009). They capitalise on the core business of the university by enabling the teaching-research nexus to flourish. Campus-based Living Labs also provide an opportunity for operational staff to share often hidden knowledge about the facilities and management of the university with students in mutually beneficial ways, potentially contributing to meeting their sustainability goals through student-derived innovation. And finally, they support universities' commitments to the UN Sustainable Development Goals under the Higher Education Sustainability Initiative.

9.3 A Transdisciplinary Living Lab: A Proposition for Collaborative Research and Learning

The conventional domain in which many universities address sustainability lies within schools of the environment, and the focus is primarily on resource management (Hoffman and Axson 2017). In contrast, Living Labs allow for the development of different models for sustainability education that could operate within and across university faculties. The challenge of introducing and standardising collaborative research across disciplinary faculties in degree programmes (see Fam et al. 2018, Chap. 7 in this book) attests to the need to consider and nurture multiple models of interdisciplinary and transdisciplinary education, of which a TDLL is one.

The TDLL aligns with Scott and Bakker (2012) view that a shift is required from technology-focused design approaches to a more practice-oriented design approach which takes into consideration the socio-technical infrastructures influencing everyday practices. A collaborative, user-focused design perspective requires users to play an active role in both generating and applying practice-based knowledge. Key to the design process aligned to the TDLL is the identification, integration and impact of users' experiences on design solutions as core stakeholders in the process. The extension of the Living Lab model is distinguished by explicitly structuring the TDLL to develop skills across three stages of the TD process, discussed in more detail below.

In this research we use the TDLL in the context of interdisciplinary design education, working with students of Fashion and Textiles, Product Design and Visual Communication. In this context, design is not one discipline but several, each with distinct knowledges, skill sets and material practices. Using the Living Lab to frame an interdisciplinary design studio brings these distinct design disciplines together while also bringing them into relationship with government, operations and industry stakeholders in a novel way. Rather than traditional 'clients', these stakeholders operated as learning partners in the project, open to the discoveries the students were making.

The TDLL disrupts conventional models of briefing students on projects and assessing how they respond to this briefing. A design brief is a written document that frames a design project and often presents a design problem that students are invited to solve in a directed way by exercising their professional knowledge and skills. In contrast, the TDLL offered opportunities for lifelong learning and collaboration beyond the confines of the discrete assessments, design briefs and subjects that often make up a university degree. Students were presented with a transdisciplinary research context, from which they formed their own responses to the context in student teams, drawing on disciplinary and personal knowledges and their collective experiences of interacting with the system as part of campus life. In contrast to the conventional 'closed brief' which design students are commonly issued as a prescriptive request for an end product, the 'open brief' offered in the TDLL required students to take an explorative approach to their investigation ideally in collaboration with relevant actors in the system, and produce their own problem-defining brief. Hummels' (2011) definition of Living Labs as 'carriers for joint education, research and valorisation' (p. 166) provides a context of inquiry with the university positioned as a site for collaborative research. In broadly briefing students on an ongoing research problem, rather than presenting a specific design-oriented question, students were invited to participate as collaborative researchers seeking to generate new knowledge with relevant stakeholders, including end users of the university waste system.

9.4 Phases of the Transdisciplinary Living Lab

The TDLL model proposed in this chapter invites students to participate in three distinct phases, augmenting Hummels' Living Lab model by incorporating aspects of Jahn et al.'s (2012) 'ideal transdisciplinary process' which seeks (1) joint problem formulation, (2) co-production of knowledge and (3) integration of knowledge for both societal benefit and scientific outcomes. The three phases include:

- *Phase 1: Entering the living lab: a personal perspective*
- This initial phase invites students from a range of design disciplines to critically reflect on their embedded views and roles and the impact on the system under investigation. Students work on understanding how they are implicated actors as well as potential designers of the system. In doing so, they begin by identifying where they are positioned within the system. In this stage students must draw on previous training in their degrees to negotiate team dynamics and the challenges of collectively responding to an open design brief. This first stage of the TDLL

requires students to respond to the problem of food waste management with expert stakeholders in the system and explore the range of possibilities for improving the situation.

- *Phase 2: The Living Lab: joint problem formulation and co-production of knowledge*
- Once students have reflected on and identified their own role in the system and have negotiated team dynamics, the next phase involves the research component of the lab. Students learn to collaboratively identify, bound, research, reflect and intervene to improve the system with relevant stakeholders and their project teams. In this phase, the research problem and questions are jointly formulated and design interventions are proposed where input from project team members and experts contributes to the identification of the most impactful point of intervention in the system under investigation.
- *Phase 3: Exiting the Living Lab*: *integrating societal and scientific benefits and a global perspective on the impact of design solutions*
- The final phase of the TDLL requires students to present and justify the scientific and societal benefits of team-oriented design solutions, and to explain the pathways to implement their designs in practice. In finally exiting the lab, students are guided to reflect on how local systems, practices and resource use impact on global systems, and in the process they communicate their research approaches, findings and reflections in public, open platforms. The skills needed include science communication, translation of research findings into accessible knowledge outputs (see Mitchell et al. 2017), relational and long-term thinking, and system-sensitive design.

While this model for the TDLL presents a structure of three distinct phases, in reality these phases are porous, malleable and fuzzy. The phases should be considered to be iterative, based on the experiences and knowledge the students gain throughout the process. For example, in gaining further insight into the broader global impact of their design interventions and everyday practices on our planet, there is the potential for students to develop personal perspectives on how a system changes. Our role as design educators is not only to prepare students for future employment as design professionals but also to influence how they might identify themselves as 'citizen scholars', participatory researchers and change agents in the world beyond the university. One of the aims of the TDLL has also been to shift the disposition of designers from producing traditional product-oriented outputs and sensitizing them to system-oriented problems where practice-based knowledge and collaborative research is key to developing long-term, system-wide solutions. The skills, methods, tools and knowledge gained throughout the lab (discussed in more detail below) are designed to be *transferable* to new contexts. As Hummels (2011, p. 165) notes, these are critical in *'forming self-directed and life-long learners, who are intrinsically motivated and who take responsibility for developing their own competencies and delivering high-quality work'*.

9.5 The Wealth from Waste Living Lab (WfWLL): A Case Study of Managing Food Waste On-Campus at UTS

The ‘Wealth from Waste’ Living Lab is a third-year design studio conducted at the University of Technology Sydney (UTS). It closely involves students, industry, government, facilities management experts and design and sustainability academics in collaboratively working toward more effectively managing food waste on-campus, with the long-term goal of processing 100% of the food waste for productive reuse within the Sydney precinct. With feedback from, and interaction with, expert stakeholders, students from Fashion and Textiles, Visual Communication and Product Design worked in teams of four to six members to apply principles of systems thinking, critical reflection and methods of service design to identify and jointly develop briefs and design interventions.

The first iteration of the studio, which ran as a 2-week intensive session in 2016, had the goal of trialling and evaluating a ‘transdisciplinary model’ of design education where educators invited students to engage in three phases of transdisciplinary practice: (1) Joint problem formation, (2) Co-creation of knowledge with relevant stakeholders implicated in the context under investigation and (3) Implementation and evaluation of the end product to determine the societal benefits and new scientific knowledge produced (Crosby et al. 2016). The second iteration of the studio, conducted from March to June 2017, aimed to test the Living Lab model by integrating TD principles, including participatory processes, integration of knowledge and context-specific problem solving with relevant stakeholders in the system. In this chapter, we draw on research conducted over multiple iterations of the studio, reflecting on its successes, challenges and adaptations based on lessons learned and feedback from students and the stakeholders involved.

The practice-based nature of the WfWLL was supported by the NSW Environmental Protection Agency (EPA), which was involved in funding the installation, research and evaluation of the viability of a food waste management technology on-campus. Students enrolling in the subject chose the ‘Wealth from Waste’ Living Lab from a range of options. This was important as it meant that we could assume the students had some level of personal commitment to sustainability and the goals of food waste management.

As an accessible output, the WfWLL adopted a continuous online class blog (See: www.wealthfromwaste.com), where students and educators shared research, ideas, reflections and feedback on designs in a dynamic open forum. The blog created an archive of ongoing learning that is never complete, challenging the idea that a problem, such as food waste management can be solved within a set period of time. The WfWLL proposes that sustainability-oriented challenges are an ongoing process of learning and adaptation, rather than an end goal. In addition, the WfWLL blog encourages students to build on previous iterations and learning of the project, rather than ‘reinventing the wheel’ each time the subject is offered.

Phase 1: Entering the Living Lab: A Personal Perspective
The students’ commitments to the WfWLL began with their embodiment embodiment of the problem of food waste from their own personal perspectives. They were encouraged to identify their own contributions to food waste on a daily basis, both on campus and within their own homes. This enabled them to develop important TD design skills such as critical self-reflection, systems diagramming/thinking, self-auditing and environmental auditing in the process. While some of these skills already exist in the curricula of the design degree at UTS, this phase applies them within a TD process. Focusing on these skills helped students to recognize that ‘digging where you stand’ is a good way to start being an active political agent when dealing with complex problems (Fry 2009, p. 224). This initial phase of the WfWLL also required students to reflect on and document how they planned to collaborate across design disciplines, on their individual strengths and weaknesses, and as a group, on how they would approach decision-making and collaborative research.

Self-Auditing and Environmental Auditing
Both iterations of the studio began with an initial introduction to systems dynamics, systems thinking and systems diagramming. Students were then invited to explore the issue of food waste production and management from their own individual perspectives. Students conducted self-audits of all the organic waste streams they produced within a 24-h period, and in the process they reflected on embedded habits, values and beliefs in managing waste streams more broadly. While auditing is a practice conventionally associated with accounting, it was adopted as a way for students to document and categories their waste as individual components who were inseparable from broader food waste systems. This enabled students to identify and position themselves as complicit actors, as well as agents of change, in the food waste system. Design skills were used in the self-auditing process with mapping, photographing, documenting, quantitative calculations and journaling of the food waste they produced. This sensitized students to the theme of the studio and primed them to identify food waste on campus as part of a broader urban food system ecology in which they are intimately involved and implicated.

In the second iteration of the studio, the authors complemented the self-auditing task by introducing the students to the concept of environmental auditing. The artist Lucas Ihlein presented his unique approach to environmental auditing which includes generating large site-specific relational drawings. Describing himself as ‘an enthusiastic amateur’, Ilhein framed the process of auditing with the idea that different knowledge perspectives are valuable and have the potential to contribute to the accounting process. In Ilhien’s project, ‘Environmental Audit’ for the exhibition ‘In the Balance: Art in a Changing World’ at the Museum of Contemporary Art in Sydney (Ihlein and Barkley 2010), Ihlein worked to ‘visually synthesise some of the complexities of balancing the environmental ledger’ (p. 103) as an invitation to others to think more deeply about what they witness, what really does make a difference, and what just makes us feel better about being environmentally conscious.

In project teams, students conducted an environmental audit of a university building. They chose one system (such as Wi-Fi, lighting, or air-conditioning) and mapped all the inputs, outputs, and human interactions before presenting their results to the group. Conducting environmental audits as amateurs contributed to the appreciation that users and observers of the system, as well as experts, have important and valuable contributions to make in identifying, visualizing and improving systems. It also demonstrated the value of making visible everyday inconspicuous systems within which students spend much of their time, yet rarely notice. The environmental auditing exercise builds and expands on students' existing design skills of active observation, mapping, sketching and diagramming as a way of thinking ecologically about the food waste system (see Frascara 2001). In her argument for Living Labs, Hummels (2011) writes *'Design students should learn to trust their senses and their intuition'*. This reflected the focus of the auditing exercises undertaken. Auditing gave students a means to explore ambiguity and open-endedness even when faced with a topic traditionally heavy in 'factual' or quantitative data. From a transdisciplinary perspective of skills development, environmental and self-auditing exercises prime students to question what valid data is, and whose perspective should be valued.

Phase 2: The Living Lab: Joint Problem Formulation and Co-production of Knowledge

Once students had entered the WfWLL, reflected on their own roles in the food waste systems and learned to negotiate team dynamics, the remainder of the WfWLL was spent on co-producing knowledge and gaining experience of the food waste system from multiple disciplinary and lay perspectives. This was done through collaborative panels, Q&A sessions and evaluation of student progress by project partners. Importantly, the end-user perspective of the system was sought, with students invited to produce primary research data to support and justify their final design interventions. Students drew from a range of system thinking tools and methods, including stakeholder mapping, 'rich pictures' (Checkland and Poulter 2006), and causal loop diagramming to enable teams to initially identify their own knowledge of the system, as well as the interactive components and critical actors in the system. Primary research methods included interviews, surveys, shadowing cleaners to identify everyday cleaning practices, and participatory observation. Below we outline the skills developed during this phase of the Lab.

Critical Thinking, Listening and Reflection

Taking the position that a variety of different perspectives on the issue of food waste management on-campus provides a richer context of the problem, the authors engaged an expert panel to work with students over the duration of the WfWLL. This was achieved in a number of ways, most successfully through a half-day presentation and Q&A where representatives from local council, the NSW Environmental Protection Authority, technology developers and UTS facilities management staff provided their own perspectives on the issue of food waste and identified where innovation was currently occurring and is expected to occur in the near future. Student engagement with expert stakeholders in the system provided not only multiple perspectives, but also insight into contested viewpoints, values, approaches and personal and organizational commitments to creating change while allowing students the opportunity to further develop skills in critical listening, thinking and reflection.

Observation

In order to inform their designs, students were required to engage in primary research. After observing the infrastructural system used to manage waste on campus as a group, doing a walk-through of the system and listening to waste management experts (cleaners and operational management staff) speak about their perspectives on the system, students identified the primary research methods matched to the project briefs they had generated in project teams. These ranged from surveys to interviewing and shadowing operational staff members. Perhaps unsurprisingly, observation, in its various forms, was by far the most commonly used method, with one student connecting it directly to the collective and ongoing process of refining the brief: *'Observation was not only crucial throughout our process, but also integral to our creation of the brief.'* And another: *'Also in the ongoing design process observation turned out to be a key research method for ideating and evaluating.'* One group conducted and recorded their observations as a video ethnography, which they said *'further corroborated the findings of the semi-structured interview by visually demonstrating in real time the confusion and difficulty surrounding the use of the existing bin system and revealing a pattern where users paused when approaching the bins before disposing of their waste.'* Another student commented: *'Observation is a method that takes many forms, but ultimately relies on all the senses to understand the behaviours of the subject.'*

System Mapping

The set of skills involved in visualising the system was broadly defined as 'system mapping'. In preparation for setting boundaries for their own projects, students were guided through a system diagramming exercise where they were introduced to concepts of systems thinking and system dynamics. Students worked in groups to brainstorm existing knowledge of complex systems within the university and interrelated components. Waste streams such as plastic, sewage, water, food, paper and the controversial waste stream of 'time' were proposed as components of embedded systems at UTS and used as prompts for introducing systems thinking. Students collaboratively mapped the waste stream and the system components involved, with questions prompting students to think about how, for example, technologies/infrastructure, resources, policies, values, practices, stakeholders and economics influence the system they mapped. The result was a collaborative visualisation of five complex systems that were largely invisible to students before the exercise. These visualisations were used to prompt discussions about the direct and indirect relationships of these system components to the management of food waste on campus.

For students, the system diagrams became a record of the transdisciplinary thinking process necessary for understanding the complex relationships between system components. It was also a visual tool for collaboratively identifying and mapping systems that was more familiar to design students than non-visual approaches to analysis. One student commented; *'It's a good way to take stock of the possibilities'*.

Other students commented: *'I like that you're thinking about everything at once, the stakeholders rather than just the design first and how the design will impact people'*. As with the personal waste audit, others identified how design skills could contribute to the process: *'I like that you can visualize, it's not a word document, it's a map of everything integrated, it forces you to think of it all at the same time'*.

Creating 'rich pictures' of the food waste system in particular, through visualising systems components was a way to explore, explain and justify design interventions. The most successful project teams combined the open-endedness of auditing with the boundary setting tasks required of system diagramming in their research. One student commented: *'For me, the most useful research method undertaken was auditing and mapping visually how the waste system works at UTS Housing … we could use this audit both for generating and evaluating our ideas from different starting points and literally see, what effect on the system it could possibly have.'*

Phase 3: Exiting the Living Lab: Integrating Societal and Scientific Benefits and a Global Perspective

Interpreting Jahn and colleagues' (2012) 'ideal transdisciplinary process' during the first iteration of the studio, we conceptualized the final phase of students' learning as a need to justify their final designs in relation to the methodological approach, the knowledge gained throughout the process and the TD skills developed (i.e. collaboration, and communication in its multiple forms, and integration of knowledge). Some students felt frustrated because they were unable to implement their design solutions in the short timeframe of the subject. The WfWLL responded to this feedback by considering the way each student exited the lab as a learning opportunity, taking their skills and knowledge of sustainability-oriented research and transdisciplinary practice into the world, as citizens, scholars and professionals.

In the final phase of the WfWLL in 2017, students were introduced to the concept of 'planetary boundaries' and the idea that there is a need for humanity to function within the boundaries of a safe operating space (Rockström et al. 2009). This introduction had two aims. The first was to broaden the perspective of the problem of food waste beyond the campus to the city, state, national and glo completed an application for a fictitious job based on the skills bal scales, making the boundaries of the Living Lab porous. The second was to support students to leave the lab with insights into the interdependences and impacts associated with system design. Students were therefore invited to reflect on their own design interventions to improve the food waste management system, and how their designs took into consideration planetary boundaries.

At this stage, class of students were introduced to a mentor who had graduated the year before, after participating in the first iteration of the WfWLL. Interestingly, the most significant questions the current students asked the mentor were to do with the relationship of the collaborative process to life after university. The mentor highlighted the importance of Phase 3 of the WfWLL and how the studio had influenced her professional life and direction. As a previous fashion student, she noted that, *'Rather than fashion, I find myself looking at positions within companies and charities that have already committed to reducing waste and making the planet more*

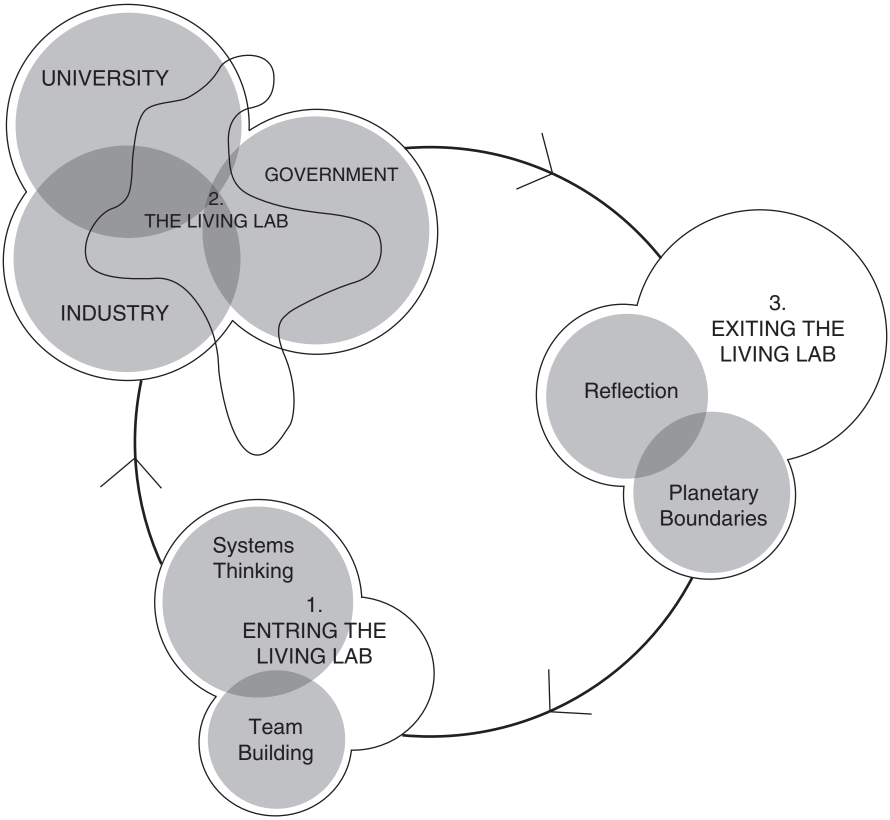

Fig. 9.1 Overview of the scope of the Wealth from Waste Living Lab (WfWLL)

sustainable … I feel I am able to make a small but important difference with others who share the same passions for sustainability and that is very important to me.’

As a final task, students were invited to develop a broader perspective on their learning through a reflection process in which they completed an application for a fictitious job based on the skills developed and experience gained in their public research on the class blog. This became an opportunity for the authors to evaluate, not only how students had incorporated a ‘global perspective’ of the potential impact of their final design solutions on the planet, but also what had been the greatest learning experience and the most valuable skills they had developed (Fig. 9.1).

One student commented: *‘One of the most influential moments I’ve experienced was to have the opportunity to attend a presentation … about the Sustainable Development Goals (SDG). I personally think that design has a power to change one’s mind, therefore, I needed to understand how habitual changes regarding food waste/organic waste disposal in general impacts us as a nation. In total SDG focused on 17 goals to achieve in the next 15 years, which opened my eyes to the possibility of design solutions in which I would love to contribute’.*

9.6 The Transdisciplinary Living Lab: Successes, Failures and Future Opportunities

The integration of a transdisciplinary process into the Living Lab model presented a number of challenges in the context in which it was tested. One set of challenges relates to the initial phase of 'joint problem formulation' and the way in which project briefs are used in design education. Keeping a brief open to be developed by students from different design disciplines requires a common language, the development of a problem statement and a joint decision on an acceptable process to tackle the design problem. It became clear from student feedback and discussion that 'briefs' are developed differently across design disciplines. For example, designers may refer to participants in a system as 'users', 'clients', 'audiences', or 'customers' depending on their training and disciplinary conventions. And they might refer to a test design as a 'prototype', 'draft', 'mock-up' or 'toile'. Finding a common way to generate and communicate a brief requires *team-based work,* which is challenging for students whose university education has primarily focused on developing disciplinary knowledge and individual assessment. Even with the experience of working in collaborative teams throughout their design degrees, students generally consider design knowledge as individually acquired rather than collaboratively developed with non-designers such as industry, government and community actors.

This is related to the challenge of facilitating learning through the use of *open briefs,* which are still relatively uncommon in design education. One student commented: *'Because we are accustomed to being given "the problem" at the beginning of an assignment, we didn't know how to move forward without one.'* For educators, open briefs require a constant responsiveness to each project team, as they raise questions about boundary setting and the developmental challenge of goal setting in teams with diverse types of members. While an open brief generates rich and diverse projects, it should be acknowledged that it is much less efficient than delivering the same brief to an entire class.

The WfWLL aimed to transcend the boundaries of disciplinary knowledge and expertise by cogenerating new knowledge from a range of design disciplines and expert contributors. Design 'solutions' were therefore not simply designs, but rather context sensitive socio-technical processes and outputs. This is clearly demonstrated in all the work produced throughout the WfWLL, but it also created frustrating limitations for students and educators. While the collaboration of three distinct design disciplines with expert stakeholders produced innovative ideas, the fact that design skills alone could not solve problems was felt during Phase 2. For instance, some design students reported that the skills of peers in the disciplines of engineering, health, journalism, or science were necessary in the implementation of their ideas.

There are other challenges specifically relating to the integration of a transdisciplinary approach to a Living Lab model. In adopting Jahn and colleagues' (2012) staged model of a transdisciplinary process, the authors took the concept of knowledge integration on board in the educational design of the programme, and introduced exercises and tools to help students articulate and develop an 'integrated design output'. Bergman and colleagues (2012) suggest a number of methods of transdisciplinary integration, including: knowledge integration through research questions and hypothesis formulation; developing effective scientific methods; and integration through the use of artefacts, services and products. However this integration remained a significant challenge for students. Analysis of the final student proposals revealed that *integrating multiple perspectives* into one final design was extremely challenging and perhaps not possible for undergraduate students within the time frame of a 12-week subject. This is in part because one final design will not always be an adequate response to a complex problem. Therefore, we as educators are challenged to re-evaluate learning objectives and assessment criteria when designing and teaching within a TDLL model.

In addition, students' attempts to integrate a global perspective, through consideration of planetary boundaries, into their final designs tended to be tokenistic and weaker than expected. While a global perspective of design impact has the potential to be incorporated into the development of future educational models, it needs to be acknowledged that this is a longer-term goal than is possible to achieve within the scope of a short subject. Moreover, the extent of this integration is difficult to assess, and the impacts are sometimes felt long after the student has left the Living Lab or university.

Of all the exercises undertaken during the studio, the personal waste audit was observed to be the most useful in helping students to situate themselves within a system and the supporting mechanisms that either reinforce or inhibit the practice of food waste management. Auditing more broadly offered a creative method and low threshold entry point for students to consider their own roles in a system, and the audit had an affinity with students' existing skills in visualization and the spatial organization of information. From a transdisciplinary perspective, auditing offered the opportunity for students to become active partners with personal knowledge to contribute.

The WfWLL model has largely received positive feedback from students. One fashion student chose the Wealth from Waste studio in 2016 due to her commitment to sustainability. She reflects that sustainability is on the minds of many of her peers, but that in the intensity of the course, they were left to pursue it as a special interest: *'Everyone should know about the planetary boundaries, it's not really a special interest. Learning more about waste systems made me realize how much I already cared about rubbish, but just didn't realize it!'*

9.7 Conclusion

The TDLL model was developed during the 'Wealth from Waste' studio between 2015 and 2017. During that time significant changes were made to incorporate a transdisciplinary approach to teaching and learning in design education. This chapter has aimed to demonstrate the potential for the TDLL to create a valuable environment for transdisciplinary learning, including the transformation of personal and disciplinary perspectives of situations and the transcendence of disciplinary boundaries in developing integrated design outputs. There is evidence that students reframed their personal and professional aspirations as designers throughout the WfWLL, and that they made connections between the design skills in their design disciplines and the TD process. These connections demonstrate the potential for the TDLL to provide insight into how universities might function as productive sites of transdisciplinary learning that shape the experiences of students for the duration of their degrees and beyond.

While the TDLL model has significant potential for sustainability educators, and for those interested in implementing programmes structured around practice-process-project learning, it also requires further research. Appropriate mechanisms to test and evaluate the learning outcomes from the model beyond the usual student survey instruments and data gathered in studios still need to be developed. Further applications of the model (which involve faculties other than design faculties, and which involve projects other than 'food waste management' projects) are needed to test the TDLL in higher education settings. In our study the process was limited to design disciplines, and the transdisciplinary problem of food waste management also requires intervention from engineers, health professionals, and scientists. The design of future TDLL projects presents logistical challenges within faculty structures, but the TDLL is also agenda setting in this regard as it operates across curricula, operations, research and engagement, and primes the university setting for further changes to disciplinary education to meet challenges of our increasingly complex world.

Acknowledgements The authors would like to acknowledge the generous support—in kind and financial—of the NSW EPA, the UTS Facilities management team, local council representatives and waste contractors in developing the UTS Transdisciplinary Living Lab.

References

Allen, J., Lopes, A., & Andrews, T. (2009). *Futures west: A design research initiative promoting sustainable futures for Western Sydney*. Paper presented at Cumulus 38°South: Hemispheric shifts across learning, teaching and research Melbourne, November 12–14.

Bammer, G. (2013). *Disciplining interdisciplinarity: Integration and implementation sciences for researching complex real-world problems*. Canberra: Austrailan National University E-Press.

Bergmann, M., Jahn, T., Knobloch, T., Krohn, W., Pohl, C., & Schramm, E. (2012). *Methods for transdisciplinary research*. Zurich: Campus Verlag.

Checkland, P., & Poulter, J. (2006). *Learning for action: A short definitive account of soft systems methodology and its use for practioners, teachers and students*. Johanneshov: Wiley.

Crosby, A., Fam, D., & Mellick Lopes, A. (2016). *Wealth from waste: A transdisciplinary approach to design education.* Open design for E-very-thing – Exploring new design purposes, Cumulus conference, Hong Kong.

Fam, D., & Crosby, A. (2017). *Wealth from waste*. https://wealthfromwaste.wordpress.com. Accessed 20 Oct 2017.

Fam, D., Leimbach, T., Kelly, S., Hitchens, L., & Callen, M. (2018). Meta-considerations for planning, introducing and standardising interdisciplinary learning in higher degree institutions.

In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary theory, practice and education*. Dordrecht: Springer.

Frascara, J. (2001). Diagramming as a way of thinking ecologically. *Visible Language, 35*(2), 165–177.

Fry, T. (2009). *Design futuring: Sustainability, ethics and new practice*. Oxford: Berg.

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy, 31*, 1257–1274.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). The new production of knowledge: The dynamics of science and research in contemporary societies. In *London: Sage*.

Hoffman, A. J., & Axson, J. L. (2017). *Innovations in cross-campus and cross-disciplinary models*. Michigan: University of Michigan.

Hummels, C. (2011). Teaching attitudes, skills, approaches, structure and tools. In B. van Abel, R. Klaassen, L. Evers, & P. Troxler (Eds.), *Open design now* (pp. 162–167). Amsterdam: Premsela, The Netherlands Institute for Design and Fashion and Waag Society.

Ihlein, L., & Barkley, G. (2010). Lucas Ihlein: environmental audit. In R. Kent (Ed.), *In the balance, art in a changing world*. Sydney: Museum of Contemporary Art.

Jahn, T., Bergmann, M., & Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics*, 79, 1–10.

Lang, D., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science*, 7(Suppl 1, 25), 25–43.

Massachusetts Institute of Technology. (2010). *Living labs*. http://livinglabs.mit.edu. Accessed 20 Feb 2017.

Mitchell, C., Cordell, D., & Fam, D. (2017). Beginning at the end: The outcome spaces framework to guide purposive transdisciplinary research. In D. Fam, C. Riedy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability* (pp. 25–38). London: Routledge.

Neuhauser, L., & Pohl, C. (2014). Integrating transdisciplinary and translational concepts and methods into graduate education. In P. T. Gibbs (Ed.), *A transdisciplinary study of higher education and professional identity*. New York: Springer.

Robinson, J. (2008). Being undisciplined: Transgressions and intersections in academia and beyond. *Futures*, 40, 70–86.

Rockström, J., Steffen, W., Noone, K., Persson, Å., et al. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society, 14*(2), 32 [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art32/.

Scott, K., & Bakker, C. (2012). Designing change by living change. *Design Studies, 33*(3), 279–297.

The European Network of Living Labs (ENoLL). (n.d.). *Open living labs*. http://www.openlivinglabs.eu. Accessed 20 Feb 2017.

United Nations. (2017). *Sustainable development knowledge platform*. https://sustainabledevelopment.un.org/sdinaction/hesi. Accessed 20 Feb 2017.

Westberg, L., & Polk, M. (2015). The role of learning in transdisciplinary research: Moving from a normative concept to an analytical tool through a practice-based approach. *Sustainability Science* (pp. 1–13).

Chapter 10
Nurturing Transdisciplinary Graduate Learning and Skills Through a Community of Practice Approach

Chris Riedy, Cynthia Mitchell, Juliet Willetts, and Ian Cunningham

10.1 Introduction

Transdisciplinary (TD) research integrates the diverse knowledge perspectives of academics and non-academics to co-create knowledge and practice for addressing contemporary problems. It is an emerging research orientation that aims to transcend narrow disciplinary worldviews, respond to complex societal problems, and critique dominant modes of learning and knowledge generation (Klein 2015). Increasingly, sustainability scholars agree that TD research is crucial for tackling global environmental and social challenges (Hirsch Hadorn et al. 2006; Lang et al. 2012; Mauser et al. 2013). While TD research is therefore well established as a normative ideal (Scholz and Steiner 2015a), it continues to face significant challenges, obstacles and constraints in practice (Lang et al. 2012; Scholz and Steiner 2015b). Our focus here is on the specific challenge of creating communities of practice for TD research, researcher development, and reflective learning within universities.

At first glance, TD research seems a poor fit for the university environment. Academic disciplines are the core components around which the bureaucracies and incentive structures of universities are based. Crossing disciplinary boundaries may be encouraged rhetorically but can be difficult in practice due to funding challenges, workload constraints and competing demands. Yet universities are also places of innovation where space can sometimes be found to test and reflect on new approaches to research. If TD research is to move from a normative ideal to a routine practice, we argue that it needs several kinds of support from universities.

First, universities need to support and encourage the practice of TD research by providing structures and incentives, including recognition and promotion, that allow and motivate scholars to come together across disciplinary boundaries. Recent

C. Riedy (✉) · C. Mitchell · J. Willetts · I. Cunningham
Institute for Sustainable Futures, University of Technology Sydney, Sydney, NSW, Australia
e-mail: criedy@uts.edu.au

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_10

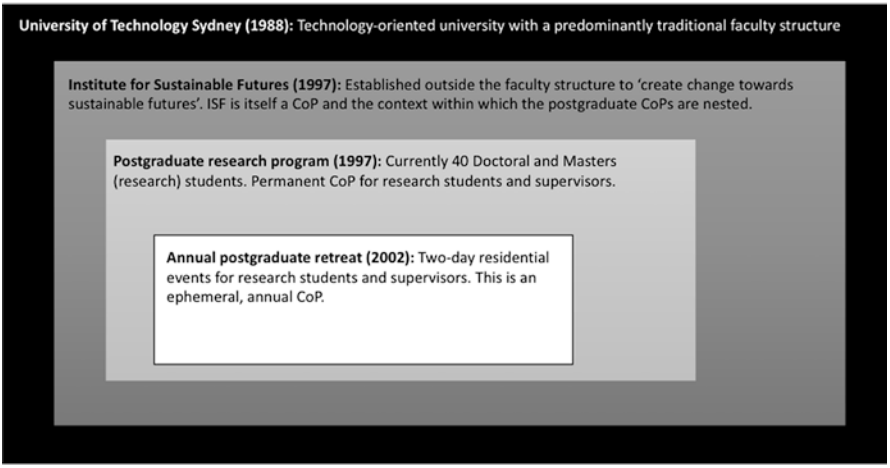

Fig. 10.1 Nested communities of practice at the Institute for Sustainable Futures (ISF)

scholarship confirms that TD research is still 'rarely recognized by professional institutions; it is still rarely taught in higher education programmes, and it is not often supported by funders of research' (Lawrence 2015, p. 1). Second, universities need to help researchers to develop the knowledge, skills and dispositions required to successfully engage in TD research (Fam et al. 2017b). Finally, universities need to create spaces to engage in collective, double-loop learning (Argyris and Schön 1996) about TD research practice. What exactly TD research is, and its implications for the way universities and scholars practice, remains emergent and contested (Scholz and Steiner 2015a). Spaces to experiment with, reflect on, and adapt TD research practice are crucial.

In this chapter, we are concerned with the second and third of these needs, both of which are concerned with learning TD research practice. Fam et al. (2017b) identify six skills and dispositions needed to be an effective TD researcher: curiosity; commitment; critical awareness; creativity; communication; and connectedness. They argue that these skills are not easily taught in a traditional way but require aspiring TD researchers to learn through practice. Further, skills like communication and connectedness clearly cannot be learned in isolation. As such, following previous scholars (Cundill et al. 2015; Willetts and Mitchell 2007), we turn to the concept of communities of practice (CoPs) to guide the development of learning spaces for aspiring TD researchers. CoPs are social learning spaces (Wenger 2010) that organize around a shared domain of interest, allowing practitioners to engage with each other, practice together and learn from each other (Cundill et al. 2015).

Specifically, we reflect here on a set of nested CoPs that have nurtured TD research and learning at the University of Technology Sydney (UTS), Australia (see Fig. 10.1). In 1997, UTS created the Institute for Sustainable Futures (ISF) with a mission to create change towards sustainable futures. As shown in Fig. 10.1, ISF provided a supportive structure for scholars to cross disciplinary boundaries because it was established outside the normal faculty structure, reporting directly to the Deputy Vice-Chancellor responsible for research. ISF was defined by its mission, not by its discipline. This created the initial conditions for a TD CoP to thrive. While ISF can itself be thought of as a CoP, our paper focuses on ISF's postgraduate programme, established in 1997 to develop new researchers through higher degree research (HDR).[1] The HDR programme became a site of innovation in TD research, initially as a way to draw together a diverse group of disparate, disconnected students. Within the HDR programme, an annual residential retreat became a key event to support collective, double-loop learning on TD research practice and researcher development. These nested spaces each constitute a CoP and together they offer the essential characteristics outlined above to support learning about TD research.

This chapter critically reflects on the role of ISF, our postgraduate research programme, and particularly our residential retreat, in building a home within a university for both doing and collectively learning about TD research. We describe the structure of our HDR programme and its conceptual origins, before focusing in on the role of our annual residential retreat. Our critical reflection on the retreat as a TD CoP is based on a thematic analysis of participant evaluations and our experiences as leaders of the retreats over the past 15 years. We draw out lessons from our practice that could assist others in creating spaces to nurture TD research and learning.

10.2 The Institute for Sustainable Futures Postgraduate Research Programme

ISF commenced in 1997 as a flagship research vehicle of the University of Technology Sydney, with a mission to create change towards sustainable futures. We do this through a combination of: high quality integrative (Boyer 1990) scholarship undertaken collaboratively with government, industry, and community organizations; engaging in and supporting public dialogue; and through our HDR programme. Unusually for a university institute, ISF's funding comes primarily from external consultancy work, rather than traditional research funding. From the outset, ISF brought together staff of different disciplinary backgrounds, who also worked across many disciplines and sectors in both our HDR programme and our funded projects. Its location outside faculty structures provided freedom for researchers from diverse backgrounds to join and work together on sustainability challenges.

By 2001, we recognized this diversity had left our HDR student group feeling individually isolated, in part because their topics appeared to bear little relation to one another. For example, topics included state government environmental reporting systems, national energy subsidies, the national residential building sector, urban transport systems, local government planning approval systems, urban water

[1] Higher degree research (HDR) is a term used in Australia to refer to postgraduate university degrees that are undertaken primarily by research rather than coursework. ISF offers two such degrees: a master's by research and a Doctor of Philosophy.

systems, and international aid and development. The students had little overlap in the content of their work, and we needed to find ways to bring them together in terms of thinking about research process. Transdisciplinarity provided the underpinning to that endeavour, and in 2002 we more formally adopted a TD approach within the HDR programme, informed by the emerging global literature and practice at that time. ISF nurtured this emerging TD CoP by establishing a business model that treated time spent on HDR supervision as equivalent to time spent on the consulting work that provides most of our income. This ensured supervisors would feel free to devote time to the CoP.

Since then, our overarching goal has been to build and continually enrich a community of scholars—a scholarly CoP. This year, through a small international study, our colleagues identified for the first time the skills and dispositions TD researchers require: curiosity; commitment; critical awareness; creativity; communication; and connectedness (Fam et al. 2017b). In mapping those to our practice, the focus of our early CoP was building critical reflection, communication and connection. Our research students came to us with abundant curiosity and a deep commitment to creating change towards sustainable futures. A focus on creativity emerged later.

Our approach to supporting both student and supervisor development in TD research comprised three key strategies: (i) Nurturing a CoP; (ii) Creating both spaces and structures to enable deep reflection and questioning; and (iii) Conducting iterative action learning cycles in the evolution of the programme. These strategies overlap—reflection and questioning support action learning, and all of these potentially contribute to building a CoP.

The concept of CoP (Cundill et al. 2015; Wenger 1998, 2010) supported our early thinking and planning. We intentionally supported three key characteristics of such communities: mutual engagement; joint enterprise; and shared repertoire (Willetts and Mitchell 2007). A CoP is a social learning system (Wenger 2010) in which members learn through active engagement and collective practice structured around a shared domain of interest. TD CoPs have some particular characteristics, in that they 'are more likely to be distinctly heterogeneous, cross-sectoral groups with a shared interest in and basic commitment to solving complex social-ecological problems' (Cundill et al. 2015). Many of our practices, including the annual residential retreat, emerged as a way to provide opportunities and reasons for our diverse group of researchers to engage with each other. The connection to the six skills and dispositions identified above is clear: a CoP helps to build connectedness, provides a space for communication and can deepen critical awareness through exposure to practitioners with different perspectives.

To increase the likelihood that our students would learn critical awareness, the creation of spaces and structures to enable deep critical reflection has been a core strategy. This focus on critical reflection is not necessarily a feature of all CoPs, but it is recognized as an important aspect of TD practice (Fam et al. 2017b). Transdisciplinarity, at a fundamental level, requires individuals to question their 'learned' ways of seeing the world, particularly in terms of ontology and epistemology. Such thinking needs intentionally created 'spaces' to build trust between individuals and support engagement in shared questioning, away from the piecemeal

Table 10.1 Mapping strategies to activities implemented to build and enrich our community of scholars

Activities	Nurturing a community of practice	Providing space and structure for reflection	Conducting action learning
Tailored induction	✓		
Monthly PG meetings	✓	✓	✓
Annual retreats	✓	✓	✓
Modules and special workshops	✓		✓
Groups for Accountability and Support (GAS)	✓	✓	
Collaborative scholarly publishing based on our programme	✓	✓	

demands of daily tasks and work. It also requires sufficient structure to guide learning, give direction and facilitate collaboration. There is a tension here between structure and emergence, or participation and reification (Wenger 2010), that we will return to later.

Lastly in terms of strategies, we have used double-loop learning and explicit action learning cycles (Schön 1987), which responded to voiced and observed needs of students and supervisors, meaning that the programme has constantly evolved. Whereas the strategy described above focused on helping students to become critically aware, this final strategy sought to ensure that the programme itself responded to changing ideas about what TD research is and how best to support students in learning and practising it. One example of this learning and reflection is a book chapter formulated around a structured reflection on how the programme was supporting students to negotiate the inevitable ‘tensions’ that arise in TD work. These tensions included, for instance, managing breadth and depth, balancing an imperative to ‘create change’ with ensuring academic rigour, dealing with the lack of rules and structure once ‘beyond’ disciplines and communicating effectively with multiple audiences (Willetts et al. 2012).

The three strategies outlined above are put into practice through six core programme activities (see Table 10.1). Students enter the programme through a tailored induction process that sets the foundation for the mutual engagement and shared repertoire element of our CoP. They then participate in: monthly student-programme meetings; an annual retreat; Groups for Accountability and Support (GAS); and a series of structured learning ‘modules’ on key aspects of TD and sustainability research. All of these activities help to build TD communication skills and a sense of connectedness, as they provide spaces for students and supervisors to regularly engage across disciplines. Finally, students and supervisors are encouraged to participate in collaborative publishing on the process and insights of our programme. Most of these activities should be familiar, but some further explanation of GAS and modules is warranted, before we turn to the annual retreat as our key focus in this paper.

Fisher et al.'s (2003) concept of Groups for Accountability and Support (GAS) as a peer support mechanism for postgraduate students was a perfect fit for our fledgling programme, and it has remained a central piece. GAS are small groups of peers (3–5 students). The composition of each GAS is overseen by the programme administrators in consultation with students, and is typically based on some combination of the research area, personalities and the stages of students in the research process. All else is at the discretion of the group—including expectations of each other; the frequency, duration, focus and structure of meetings; the depth of feedback sought; and the kind of insights/drafts/questions shared. From the programme perspective, the intention is a focus on three elements: supporting each other (connectedness); holding each other accountable (commitment); and building reflection into their practice (critical awareness).

The 'modules' have emerged from our learning-by-doing approach, and the exploration and conceptual development of common threads at retreats. The modules represent the distilled wisdom of the programme, and comprise key topics of relevance to transdisciplinary research, including: theories of change; epistemology and ontology; critical thinking; futures thinking; systems practice; and transdisciplinary research practice. These modules are run as courses on a regular basis, and are facilitated by a combination of students and supervisors. While other activities focus on building the skills and dispositions for TD research, these modules focus more on equipping students with the knowledge they need for TD research on sustainable futures.

From a theoretical perspective, our programme has several roots. The action research/action learning orientation has already been made clear, and the focus is therefore on critical reflection. Our starting point was Boyer's (1990) Scholarship of Integration, which he positioned as the next step beyond 'Discovery' and 'Application'. For distinguishing our transdisciplinary work from other cross-disciplinary work, we drew on Thompson Klein (2004) and Jantsch (1970), with their focus on transdisciplinarity's intent to call into question disciplinary knowledge, and to find new ways to articulate the differences between different forms of knowledge. Jantsch's purposive intent fitted well with ISF's mission of creating change. As the experience of our CoP deepened, we theorized our own practice and contributed to the TD discourse, most recently concerning what constitutes 'quality' in evaluating TD doctoral research (Willetts and Mitchell 2017).

One activity—our annual retreat—played a particularly pivotal role in nurturing our fledgling CoP, and it is to this activity that we now turn.

10.3 The Annual Postgraduate Retreat: A Critical Reflection

The central intent of our first annual retreat in 2002 was to build a community of scholars—to help our postgraduate students see that they had much in common, despite engaging in disparate research topics. However, we recognized that the experience of being exposed to distinctly different knowledge perspectives associated with other disciplines can be cognitively and emotionally challenging, leading to 'disorienting dilemmas' and perspective transformation (Palmer et al. 2009; Taylor 2007). We felt the need to provide a safe space in which it was possible to experience, explore, and make sense of disorienting dilemmas, while also building the connectedness needed for TD research. Schumacher College's model of transformative learning for sustainable living provided a model that met these needs. This kind of cognitive and emotional work benefits from a sense of belonging (connectedness), so foregrounding the business of building a community was also intentional: for the first decade, we chose locations that not only offered inspiring natural surroundings, but also required us to prepare our meals together, providing diverse opportunities for nurturing multi-dimensional individual and community relationships well beyond conventional office interactions. Further, we chose locations away from the office and encouraged participants to stay overnight by funding accommodation. The literature on TD research stresses the time required for such work, so it was crucial to secure uninterrupted time by reducing the distraction of other work.

Each retreat is a 2-day event, open to all graduate research students and supervisors, where participants engage in facilitated activities connected to one or more overall event themes. Since mutual engagement is dependent on 'being included in what matters' (Wenger 1998, p. 74), students and supervisors collaboratively organize and facilitate the learning experience in annual retreats so that the activities of the retreat are relevant for the current cohort. Themes have included TD research, change creation, systems thinking, theories of change, writing and publishing and epistemology. Typically, there is a mix of sessions requiring deep theoretical engagement oriented towards intellectual leaps—that is, collaboratively generating new insights for our practice, such as using Glassick et al.'s (1997) scholarship criteria to explore what might constitute quality transdisciplinary research—and those that are more focused on practical 'tips and tricks' for successfully completing graduate research.

The annual retreats represent the central investment in our programme, and they provide a regular space for us to revisit, enliven, and remake the mutual engagements, joint enterprises, and shared repertoires that comprise our community of practice. We would love to hold them more frequently but are constrained by available resources— both funds, and the willingness of participants, particularly supervisors, to commit the necessary time. The discussion below critically reflects on our experiences with the retreat over the past 15 years to draw out lessons for practice. We draw on two data sources. First, each of us has participated in the retreats as an organizer, research supervisor, or student. Collectively we have led and participated in all of them. We therefore draw on our own personal reflections on the retreats and how they have developed over time. Second, each retreat is evaluated on completion by seeking structured feedback from participants. We coded and analyzed this feedback using NVivo (qualitative research software) to identify and confirm themes emerging from participant experiences.

10.3.1 Finding a Common Domain

COPs form around shared domains of practice. As already noted—beyond a shared interest in research that creates change towards sustainable futures—our students are not engaged in common content. To provide a common domain for our retreats, and to build the connectedness needed for TD research, we adopted and maintain a focus on common processes—TD research practice and the shared challenges of higher degree research. The risk here is that the shared domain becomes too high level and abstract to remain engaging. To keep the retreats relevant, we therefore try to bring each participant's individual research into the collective space in a meaningful way.

One way in which we do this is through designing and working with 'boundary objects'. A boundary object is an abstract or concrete object that inhabits 'several intersecting social worlds', and has different meaning in each of those worlds but enough common structure to make it recognizable (Star and Griesemer 1989, p. 393). In a TD research context, those different social worlds are different disciplines or knowledge perspectives. A boundary object provides a space for people to engage across disciplinary boundaries, offering a means of translation between disciplines.

We have used boundary objects in our retreats for many years, although we have only very recently labelled them as such. At a high level, the retreat itself is a boundary object—a space where everyone is welcome to have input regardless of disciplinary perspective. More tangibly, we use activities such as affinity mapping, collective drawing, collage, debates and role plays to create spaces where disciplinary expertise is no longer primary. Instead, participants engage together in the collective, often physical, task of creating that particular boundary object. These activities have the added benefit of stimulating creativity, a key practice for TD researchers (Fam et al. 2017b).

For example, in the 2011 retreat, we focused one day of the retreat on 'theories of change'. Our goal was to combine our respective disciplinary knowledge on how change happens and develop a set of shared principles and questions (a framework) for assessing theories of change. This framework became our boundary object. The concept of a 'theory of change' is sufficiently broad to have meaning across different disciplines and we were able to come together through the physical task of mapping and grouping concepts on cards (see Fig. 10.2). One participant noted the value of:

> Seeing the theories of change framework come together through the group process. The collective intelligence involved in organizing and grouping the many questions we'd come up with was amazing.

Boundary objects harness this collective intelligence to achieve transdisciplinary insights together.

If the retreat operated only at this cross-boundary level, participants might find it difficult to apply the emerging insights to their own research, so we also work hard to ensure that activities and boundary objects give participants an opportunity to

Fig. 10.2 Working together on a framework for assessing theories of change

ground the practice in their own research projects. Most sessions include an activity asking participants to reflect on the application to their own research, or to contribute insights from their own research. We do not always get the balance right between activities that work at a more conceptual level and those that have practical relevance to the participants' individual research projects. However, the evaluation at the end of each retreat provides an opportunity to redress the balance the following year.

10.3.2 Creating a Nurturing Space

TD research is a challenging intellectual project that requires researchers to deeply reflect and struggle to grasp other perspectives. As noted above, disorienting dilemmas and challenges to closely-held perspectives are common. This kind of work can be exhausting and a retreat full of such work would leave participants emotionally drained. We therefore work hard to create a safe and nurturing space by balancing hard intellectual work with opportunities for fun and recharging in nature.

Holding the retreat in a nurturing location has been important. The retreat is consciously designed in a way that involves removing ourselves from our daily environment, in a natural setting, to give opportunity for different ways of interacting and reinvigorating this connection to the natural world. Retreat locations have included hostels in or close to national parks, large rented houses in forest settings, and beachside holiday parks. One location we used three times involved a ferry trip and a short walk to reach the location, which participants welcomed as offering "*an important experiential shift*", and "*truly getting AWAY from the daily grind*".

Participant reflections on the retreat have often mentioned the value that being in a natural environment held for them. For instance, the importance of "*being immersed in nature*", reference to "*the early morning swim before sunrise was magic*", "*the beauty of country*" and "*the setting and the wildlife was very special*".

We balance 'formal' structured sessions with informal time to have fun together through evening activities such as debates and storytelling, as well as space for bushwalks, other activities and non-structured time. Students afterwards have reflected on the importance of having fun together, including reports of lots of laughter, "*laughing, drinking, eating, walking*" and "*the hilarious debate*". Informal time is generally highly valued by participants: *"[I] felt the informal time was good as it allowed [a] chance to chat to people, think and recharge without rushing back to work or meals*" and "*I think it is great to be able to go out with everyone to a restaurant after the day's session and unwind*". This extended to the chance to nurture relationships between students and supervisors: "*Yes, [I] thought the ISF collegiate environment was enhanced by the retreat, not just among students but between staff and students—[I] think the breaking bread and dinner/lunch/bushwalk discussions help this as much as the formal sessions*." Some participants also felt such informal time was needed, given the intellectual intensity of other parts of the programme: "*something different to intellectual discussion*". Yet others also valued being given 'space' for subconscious thoughts to take place and digest the intellectual stimulation: "*the free time was really good. Going for a walk with a bunch of others and also having time to just sit on a rock alone and watch the sunset was fantastic for getting to know people and for processing (mostly subconsciously) what we were talking about*."

In building our COP, providing these opportunities for practitioners to bond and feel like a community (i.e. building connectedness) has been as important as the intellectual work we have done together.

10.3.3 Crossing the Boundary: Entering and Leaving a Community of Practice

A challenge faced by any CoP is how to effectively bring people into a space that is characterized by established relationships and practices—what Wenger (2010, p. 181) calls the 'regime of competence of a community'. Learning together in a CoP inevitably creates boundaries between those who have engaged in the learning journey together and those who have not. Crossing the boundary into a CoP can be a daunting experience. Entrants can experience a steep learning curve that 'entails realignment' and 'becoming a certain person' (Wenger 2010, p. 181). At the start of their engagement with the CoP, it will feel like they are being changed by the CoP; it is only later that their experience and identity can start to change the nature of the CoP (Wenger 2010). In our experience, the challenge is even greater when entering a TD CoP, as the potential for the disorienting dilemmas and perspectival challenges described above is stronger due to the diverse knowledge perspectives of the participants.

Despite these challenges, bringing new participants into a CoP is crucial. Wenger (2010, p. 191) notes that a community can become 'too strongly identified with itself, prone to groupthink, closed, or inbred' if it does not bring in fresh perspectives. Further, for a CoP whose primary members are HDR students, continual turnover in membership is inevitable as students complete their degrees and move on. Each year, our retreat has students and supervisors participating in their first retreat alongside more experienced students and supervisors. The challenge is to introduce new participants to the established practices of the CoP, while remaining sufficiently open to changes in practice that those new participants might trigger. As Wenger (2010, p. 180) puts it: 'Remaining on a learning edge takes a delicate balancing act between honoring the history of the practice and shaking free from it'.

In our HDR programme, we use induction processes and introductions at monthly student meetings to begin easing new students into the CoP. However, a student's first retreat is a key moment for bringing them across the boundary into the CoP and building their skills and dispositions for critical awareness. We have not always done this well. In the first few years of the retreat, supervisors and current students were on a joint learning journey, generating new ideas and practices together. In 2005, some members of the original cohort of students that engaged in the first retreats had submitted their theses or graduated, and new students were entering the programme. The retreat opened with a deep discussion on transdisciplinarity, epistemology and theoretical frameworks—terms that the participants in the early retreats had become quite familiar with. In a memorable intervention, one new student pointed out how difficult it was for them to engage with this complex, jargon-heavy content without any easing into the space. Our evaluation notes that year noted the 'lack of an appropriate starting point to ground the day'.

From 2006 onwards, we have always included an introductory session designed to help provide a 'soft landing', or 'transition into retreat mode'. Sometimes this has incorporated icebreaker activities to build trust between participants. Sometimes it emphasizes points such as the importance of being comfortable with feeling uncomfortable, given that cognitive dissonance is a key part of genuine learning. Prefacing the retreat with experiences participants might expect to have has been an important and valuable step: "*It was very useful of Chris to highlight some of the experiences we should expect to have during the retreat at the outset. I experienced a range of feelings and thinking now of Chris's warning at the beginning, I feel more comfortable with this range of feelings*." The introduction always emphasizes the history of our retreat programme and our CoP, acknowledging the reasons for holding retreats, what we have achieved in previous years and what we plan to achieve that year. This has become an important ritual to welcome new participants into the CoP. This change in the structure of our retreat is an example of a new voice changing the nature of the CoP in a valuable way.

The effectiveness of these rituals varies, often as a function of disciplinary background. Participants provide reflections such as: "*I think a non-threatening space was properly established for exchange and interested consideration of views (a true sign of intellectual community), and that social experience established the foundation for future informal exchange*". And also: "*I like[d] the 'gracious space' at the* *retreat with everyone... listening with 'interest, not judgement'*". However, the challenge remains, as one 2011 participant noted: "*Lots of jargon used and everyday terms used in particular context (wicked problems, TD, ontological, epistemological…) which can be alienating*".

While we have improved at welcoming participants into the retreat, we have been less successful at creating rituals to acknowledge the contributions of CoP participants as they move out of the retreat space. Once a student reaches the intense writing stage of their research project, their motivation to engage in the retreat declines in favour of their desire not to take time away from their deadline. As such, CoP participants tend to 'fade out' of the community without much fanfare. They appear at one retreat and then are not there at the next. In recent years, we have experimented with involving alumni in the retreat, to pass on their experiences as people who have made it 'out the other side'. This has been a very effective way to acknowledge former CoP participants as fully-fledged experts and contributors to our community of scholars. We are therefore considering a new practice of inviting new alumni to participate in the retreat immediately after they graduate as a way of more appropriately recognizing their graduation from our CoP. We are also considering the incorporation of a writing retreat into the programme to provide greater incentives for late-stage students to continue to participate.

10.3.4 Balancing Tensions

Balancing tensions is core to the lived experience of supervising and undertaking a TD PhD (Willetts et al. 2012). Wenger (2010, p. 179) notes various tensions inherent in the concept of communities of practice as part of 'a framework for thinking about learning in its social dimensions'. We have already identified two such tensions above: the tension between working on a common domain and remaining relevant to individual research needs; and the tension between teaching new participants the practices of the CoP and remaining open to new practices they may bring with them. Two more tensions are worth exploring here.

The first is a tension between student and programme leadership, which resonates with Wenger's (2010, p. 195) concept of stewardship governance versus emergent governance. Stewardship focuses on the existing identity of the community and its competencies, requiring new and old practitioners to position themselves and their knowledge within the collective history, whereas emergent governance responds to individuals as nodes in a network. At the simplest level, this could be interpreted as programme leaders acting as stewards, and students/supervisors being nodes delivering emergence. However, our experience has been more subtle—the degree of skill, insight, knowledge and experience in particular topics varies enormously across the entire group, so the tension is to balance the need to deliver what participants are asking for each year, with the capacity of those who choose to step up to deliver retreat sessions each year. While we prefer members of the CoP to design and deliver the retreat, we do not always have the necessary knowledge and skills within the CoP to do so. Feedback in 2013 and 2017 indicated that we had swung too far towards using retreat facilitation as a learning activity for students, and in the process failed to secure sufficient expert input on some of the desired topics. This resulted in 'the blind leading the blind'. So there is a balance to seek between setting and teaching (stewarding) a curriculum, and supporting students to emerge as practitioners in their own right.

Second, in Wenger's positioning of communities of practice as systems of practice, he notes that 'the learning and innovative potential of the whole system lies in the coexistence of depth within practices and active boundaries across practices' (Wenger 2010, pp. 183–184). In other words, there is a profound tension between common ground and dissonance. Members of the community can provide some degree of dissonance, but the opportunity remains for us to bring in external voices with different views to our own to continually challenge and grow our practice.

When we get the balance wrong with respect to either of these tensions, it usually becomes apparent in feedback after the retreat, and we then need to experiment the following year with changes to the programme to better resolve the tensions. TD research practice is itself still in a period of development and definition (Fam et al. 2017a), so it is not surprising that we find ourselves still experimenting with the best ways to manage these tensions at each retreat. This balancing process is constant, and if we lose sight of any of these tensions for a while they tend to re-emerge.

10.3.5 Trust As the 'Glue' for a Community of Practice

As discussed above, the retreat includes both structured, facilitated activities, and space for informal time and pure fun. This design is purposeful in that it values personal connections between students, and between students and supervisors. Trust lies at the heart of this design and thinking, and has proved itself an essential ingredient for the group to make collective steps forward together intellectually. An oft-quoted response to evaluation questions about the 'best thing' about the retreat has been the social aspects: "*Being with such a great bunch of people for a couple of days*" and "*The best thing about the retreat was that it provided an opportunity to get to know students and their research topics better. It also allowed time to get to know staff as well as students in a relaxed informal setting.*" Below we discuss how we have sought to advance our CoP by nurturing trust between participants.

For a CoP to thrive, the participants need to get to know each other and develop trust and a spirit of exchange. The retreat is a key space for participants who may rarely interact elsewhere to establish bonds. Repeated evaluation responses have noted both expectations (hopes) to 'get to know' others, and confirmation that this was achieved. For instance one student expected to: "*bond with other postgraduates and get to know staff better (the retreat lived up to this expectation admirably—learned a lot about other postgraduates and staff and enjoyed many serendipitous and illuminating conversations)*". Other students have specifically noted the link between trust and exchange: "*there were more people at this retreat than previously so I still feel like I haven't fully connected with every person in the group on a personal basis and would like to do so as I think these connections help build trust which is essential to have intimate dialogue at a deeper level and each of us to question ourselves at a deeper level.*"

For some participants, the personal connections generated were important for their sense of self and for taking inspiration from others. For example: "*spending some time with fellow travellers, it is really good to be fully reminded that other folks are out there walking parallel paths across the same inspiring but rocky terrain*", and "*having the opportunity to hang out with interesting and interested people who are willing to share and help where they can*". Demonstrating the value of this support, another participant wrote that: "*seeing where others are on their journey did two things: sharing with those at an earlier stage gave me a little affirmation that I really have made some progress and; listening to those who are 'all but' reminded me of where I need to get if I am to finish this thing. In combination, they gave me a cautious confidence that I can do it.*"

At times in the structure of the retreat, specific activities have been included which are designed to build trust. At one particular retreat an ice-breaker activity was introduced where participants needed to put their full trust in a fellow participant. The evaluations of that retreat demonstrate the importance that activity held for many participants. For example: "*the falling activity was an excellent trust-building exercise and again, I believe it set the tone by encouraging people to open up and have a bit more trust in each other to put forth their ideas and opinions during the two days*". Another participant reported: "*the 'game' entry-point-to-retreat-mode was very well chosen; it was not merely an ice-breaker but provided a couple of insights into ourselves and each other.*" In 2017, we used an activity with coloured yarn to make the common ground between participants tangible as a web of relationships (see Fig. 10.3). CoPs for TD research cannot neglect the important task of investing in and building trusting relationships.

10.3.6 Building Benches for Outsiders

Our final reflection is about ways of spreading what we learn in our CoP and widening participation. We like Cundill et al.'s (2015) idea of "building benches for outsiders". They note that CoPs have 'peripheral participants' and 'intellectual neighbours' that do not participate fully in the CoP but are nevertheless interested in its topics and practices. This kind of participation is legitimate and valuable, and should be encouraged.

For us, research staff and students at UTS that are not directly involved in our HDR programme are important peripheral participants. Many are interested in innovative processes of HDR supervision and TD research, and some are interested in sustainability. The learning modules discussed previously have become a crucial way of connecting with this broader community and sharing insights that have emerged in the core CoP.

Fig. 10.3 Representing our common ground with coloured yarn

Alongside the other benefits of our retreats, they act as sites of innovation to develop and refine new ideas on TD research for sustainability. Our modules began as sessions that were first tested and developed at a retreat. They are now established half- or full-day workshops that we offer to others at ISF and UTS, and we plan to open them to participants outside the university. These modules are our 'benches for outsiders', allowing those who are not members of the CoP to observe the fruits of our engagement without broadening the CoP itself to the point that it becomes unwieldy.

10.4 Reflections and Concluding Remarks

We have learned much through the experience of developing, maintaining, and enriching our community of TD postgraduate scholars. We believe this learning could have value for others, so we have sought to capture elements in publications (Fam et al. 2017a; Willetts et al. 2012; Willetts and Mitchell 2007, 2017), and practical guidance materials (Mitchell 2009). Perhaps of more value are our reflections on our practice. What has become clear is that the landscape of TD research is rocky terrain for supervisors and students alike, and such terrain benefits enormously from, indeed, perhaps requires, an annual retreat or other similar activity, for all the reasons outlined above. Our reflections in this chapter demonstrate that much of the work of building a CoP is social and relational rather than intellectual and domain-focused (although those aspects remain important). An annual retreat provides a social focal point for a CoP that builds the trust needed to engage in deep social learning.

Other institutions could seek to establish CoPs that exhibit some of the characteristics of the one we have developed at ISF, including an annual retreat or similar as one component of a wider set of activities and strategies that build the trust and space needed to develop TD practice amongst students and supervisors alike. What we have always done, and what we recommend above all else, is to be responsive, to get feedback, to set up learning loops, in order to provide a reliable foundation for the ongoing renewal and reconstruction needed to meet the needs of the current cohort of students and supervisors.

Acknowledgements Our thanks to all the members of our community of practice over the years who have contributed to the thinking in this chapter.

References

Argyris, C., & Schön, D. A. (1996). *Organizational learning II: Theory, method, and practice*. New York: Addison-Wesley.

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. Princeton: Carnegie Foundation for the Advancement of Teaching.

Cundill, G., Roux, D. J., & Parker, J. N. (2015). Nurturing communities of practice for transdisciplinary research. *Ecology and Society, 20*(2). https://doi.org/10.5751/ES-07580-200222.

Fam, D., Palmer, J., Riedy, C., & Mitchell, C. (Eds.). (2017a). *Transdisciplinary research and practice for sustainability outcomes*. London: Routledge.

Fam, D., Smith, T., & Cordell, D. (2017b). Being a transdisciplinary researcher: Skills and dispositions fostering competence in transdisciplinary research and practice. In D. Fam, J. Palmer, C. Riedy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability outcomes* (pp. 77–92). London/New York: Routledge.

Fisher, K., Bennett-Levy, J., & Irwin, R. (2003). *What a GAS! Action research as a peer support process for postgraduate students*. Lismore: Southern Cross University.

Glassick, C. E., Huber, M. T., Maeroff, G. I., Boyer, E. L., & Carnegie Foundation for the Advancement of Teaching. (1997). *Scholarship assessed: Evaluation of the professoriate*. San Francisco: Jossey-Bass.

Hirsch Hadorn, G., Bradley, D., Pohl, C., Rist, S., & Wiesmann, U. (2006). Implications of transdisciplinarity for sustainability research. *Ecological Economics, 60*, 119–128.

Jantsch, E. (1970). Inter- and transdisciplinary university: A systems approach to education and innovation. *Policy Sciences, 1*, 403–428.

Klein, J. T. (2004). Interdisciplinarity and complexity: An evolving relationship. *Emergence: Complexity and Organization, 6*(1–2), 2–10.

Klein, J. T. (2015). Reprint of "discourses of transdisciplinarity: Looking back to the future". *Futures, 65*, 10–16. https://doi.org/10.1016/j.futures.2015.01.003.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., et al. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science, 7*, 25–43. https://doi.org/10.1007/s11625-011-0149-x.

Lawrence, R. J. (2015). Advances in transdisciplinarity: Epistemologies, methodologies and processes. *Futures, 65*, 1–9. https://doi.org/10.1016/j.futures.2014.11.007.

Mauser, W., Klepper, G., Rice, M., Schmalzbauer, B. S., Hackmann, H., Leemans, R., & Moore, H. (2013). Transdisciplinary global change research: The co-creation of knowledge for sustainability. *Current Opinion in Environmental Sustainability, 5*(3–4), 420–431. https://doi.org/10.1016/j.cosust.2013.07.001.

Mitchell, C. (2009). *Quality in interdisciplinary and transdisciplinary postgraduate research and its supervision: Ideas for good practice*. Sydney: University of Technology.

Palmer, J., Smith, T., Willetts, J., & Mitchell, C. (2009). Creativity, ethics and transformation: Key factors in a transdisciplinary application of systems methodology to resolving wicked problems in sustainability. In J. Sheffield (Ed.), *Systemic development: Local solutions in a global environment* (pp. 69–78). Goodyear: ISCE Publishing.

Scholz, R. W., & Steiner, G. (2015a). The real type and ideal type of transdisciplinary processes: Part I – Theoretical foundations. *Sustainability Science, 10*(4), 527–544. https://doi.org/10.1007/s11625-015-0326-4.

Scholz, R. W., & Steiner, G. (2015b). The real type and ideal type of transdisciplinary processes: Part II – What constraints and obstacles do we meet in practice? *Sustainability Science, 10*(4), 653–671. https://doi.org/10.1007/s11625-015-0327-3.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. San Francisco: Basic Books Inc. https://doi.org/10.1182/blood-2010-02-266338.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, "translations" and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–39. *Social Studies of Science, 19*, 387–420.

Taylor, E. W. (2007). An update of transformative learning theory: a critical review of the empirical research (1999–2005). *International Journal of Lifelong Education, 26*(2), 173–191. https://doi.org/10.1080/02601370701219475.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.

Wenger, E. (2010). Communities of practice and social learning systems: The career of a concept. In C. Blackmore (Ed.), *Social learning systems and communities of practice* (pp. 179–198). London: Springer. https://doi.org/10.1007/978-1-84996-133-2.

Willetts, J., & Mitchell, C. (2007). Learning to be a "transdisciplinary" sustainability researcher: A community of practice approach. In R. Attwater & J. Merson (Eds.), *Proceedings of the 12th ANZSYS conference – Sustaining our social and natural capital* (pp. 398–405). Mansfield: ISCE Publishing.

Willetts, J., & Mitchell, C. (2017). Assessing transdisciplinary doctoral research: Quality criteria and implications for the examination process. In D. Fam, J. Palmer, C. Riedy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability outcomes* (pp. 122–136). London: Routledge.

Willetts, J., Mitchell, C., Abeysuriya, K., & Fam, D. (2012). Creative tensions: Negotiating the multiple dimensions of a transdisciplinary doctorate. In A. Lee & S. Danby (Eds.), *Reshaping doctoral education: Changing approaches and pedagogies*. London: Routledge.

Chapter 11
Making Collective Learning Coherent: An Adaptive Approach to the Practice of Transdisciplinary Pedagogy

Elizabeth Clarke and Craig Ashhurst

11.1 Prologue

On a cool sunny spring morning, we set out from Canberra to drive the 400 or so kilometres to our Sustainable Rural Systems field trip destination in the Murrumbidgee Valley—three teaching staff and 35 students. We planned to meet a wide range of people in the Valley, including food producers, irrigation managers, industry organisations, park rangers, food processors. On board the buses were teachers and students from very different backgrounds including biology, human ecology, agriculture, history, geography, law, and political science. As we swung into Northbourne Avenue we made an impressive cavalcade of three mini-buses and a good old Aussie Ute (pickup truck). We had a lot of driving ahead of us—4 hours there and back, and many hours of driving between the farms, businesses, environmental reserves and offices we planned to visit in the four-day trip to explore different perspectives and approaches to land management and livelihoods in the Murrumbidgee Valley. But these many hours behind the wheel were not wasted. In fact, these vehicles afforded excellent teaching environments for us. The mini-buses were kitted out with sound ports to plug in various phones and iPods, so there was a constant sharing of, and commenting about, various music and tastes. Snacks and drinks made their way up and down the bus, and the talk and the jokes flew fast.

In addition, the front seat was dubbed the 'Navigator's' seat, where duties ranged from navigating via the iPad and taking photos, to mobile phone communication with the other vehicles, but most importantly, it was a place to have a one-on-one

E. Clarke (✉)
Leuphana University, Lüneburg, Germany

Australian National University, Canberra, ACT, Australia
e-mail: elizabeth.clarke@leuphana.de

C. Ashhurst
Australian National University, Canberra, ACT, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_11

tutorial with the driver. This position was regularly rotated so that all the students got this opportunity. If there was a group that wanted a similar consultation, they travelled in the ute, which afforded the possibility of a four- or five-way conversation. The buses, unlike a traditional classroom, acted as a "leveler" and boundary object, creating an environment where staff and students became fellow travelers, and equal partners in learning.

While generally the teaching staff did the bulk of the driving, the students also took their turns. There were jokes about relative driving skills and a light-hearted rivalry between the different bus "crews". Rest stops allowed the opportunity for a quick game of soccer or a play on the local swings, plus the occasional foray into a supermarket for ingredients for the evening meal.

So. what might seem to have been many hours wasted driving became a learning space with many opportunities and affordances. These included time for one-on-one and larger group consultation and discussion about the field trip and key learnings, as well as a great opportunity for teaching staff and students to bond and reinforce a collective learning environment which was fun, light-hearted but productive. While field trips are a familiar learning environment for both students and teachers, reframing them in terms of adaptation for a more transdisciplinary pedagogy opens up greater possibilities and affordances, not just for content learning, but for the development of key life skills, including the ability to engage with uncertainty, complexity and diversity, develop relationships and trust, and to think creatively, logically, flexibly and critically (McGregor 2017). This is particularly relevant in our area of the curriculum, where we convened subjects on society and environmental change perspectives in the Anthropocene, and system based approaches to sustainability, particularly in rural and food systems contexts. In these cases, there are multiple possible realities and a variety of perspectives for problem framing which presents interesting challenges for teaching.

11.2 Introduction

The chapters in the first section of this book have described the growing and changing understanding of transdisciplinary collaborative research and its links with collective learning. There is an extensive literature on approaches to transdisciplinary education (for which there is no single pedagogy) (See: Klein 2018, Chap. 2 in this book). This literature emphasizes collective learning across disciplinary and practice boundaries, dealing with complexity, with an emphasis on active learning (See also Ross and Mitchell 2018, Chap. 4 in this book; Prior et al. 2018, Chap. 5, in this book; McGregor 2017). But this chapter draws primarily on our own experiences. The chapters in this section (on transdisciplinary learning (education) focus on the pedagogical issues arising from attempting to integrate transdisciplinarity into tertiary institutions. This chapter draws on our own collaborative experiences of research and teaching and provides a bridge to the next section on case studies.

For most university teachers, traditional disciplinary teaching is still relevant and appropriate. However, the process of shifting from traditional, discipline-based conceptions of pedagogy towards a more transdisciplinary approach requires adaptation of their thinking and practice, which flows through to the way in which they use and adapt learning spaces.

In this chapter, we identify four key adaptive shifts that we see as fundamental to this move towards transdisciplinary pedagogy (see Sect. 11.3). We have limited our focus to shifts at the micro scale of the classroom or learning space, rather than shifts at the faculty or institutional level. We do this to enable teachers and students to maintain or reclaim agency in the pedagogical process at the classroom or micro level. This is particularly important for learning outcomes, given that greater control over their environment is identified as a key success factor in student learning (Kaplan and Haenlein 2016).

Our focus on the micro context, which includes space, time, things and socialities, has been an emerging area of study in education (Fenwick et al. 2011) under the umbrella term of 'sociomaterial' that describes the 'constitutive entanglement of the social and the material in everyday life' (Orlikowski 2007, p. 1435). It is a holistic, multi-dimensional, systems-based approach, in which neither the material nor the social is studied in isolation. Instead, we view our pedagogical context as an assemblage or a gathering of people and things that combine to form a whole that is greater than and different to its parts. Treating the whole learning environment as a 'sociomaterial assemblage' allows us to consider the connections and relationships in a set of conditions that enable or constrain different forms of action and interaction.

11.3 Shifting from a Traditional to a More Transdisciplinary Pedagogy

The shift from traditional to transdisciplinary pedagogy has in our case meant drawing on a range of disciplinary areas such as ecology, human ecology, biology, anthropology, sociology, geography, education, organizational studies, psychology, art, history and agricultural science. Some of these are from our own academic backgrounds and others we have drawn on from the literature and also from invited speakers and, on field trips, the practitioners. It is even difficult for us to be clear about which disciplines we are combining, given that our primary focus is on the problem rather than disciplinary knowledge.

In our experience, the reality of transdisciplinary teaching and learning does not start from a blank slate. We inherit socio-material assemblages that are legacies from previous teaching environments. Considering these legacies enables us to gain insight into how, through adapting and melding these highly complex environments, we can provide the best possible learning experiences for our students.

The rate of change and innovation in the thinking of individual university lecturers can far outpace change at the faculty or institutional scale. For students, this can be perceived as an inconsistency between our espoused pedagogical goals and approaches, and the sociomaterial assemblages they are actually learning in. To re-create a sense of consistency necessitates a shift in both thinking and action. To illustrate this, we have chosen to focus on four key principle-based shifts from traditional to more transdisciplinary principles for research and education. These shifts are drawn from the principles for transdisciplinary practice identified by Clarke (2016) and they align with the shifts in pedagogy outlined by Mulcahy et al. (2015). The four principle-based shifts are:

1. the shift from a disciplinary foundation to a problem focus
2. the shift from a unified, hegemonic approach to foundational thinking (ontology and epistemology) to embracing a diverse, inclusive plurality of world-views
3. the shift from compartmentalization of knowledge, to knowledge co-production as a human and social process
4. the shift from traditional uses of space, time and things to new, more flexible and dynamic arrangements.

In a university setting these sorts of shifts are highly complex and multifaceted, with change taking place at different rates over semesters and years. Therefore, to aid in our explanation, we use a series of epistemic lenses, which we outline in the next section.

11.4 Epistemic Dimensions: Multiple Ways of Understanding the Shifts

Addressing the complex problems of the Anthropocene (frequently termed wicked problems) requires consideration of multiple perspectives. This idea of multiplicity is foundational to transdisciplinarity and collective learning. Brown and Harris (2014) have proposed that all humans are capable of multiple ways of understanding beyond what is normally seen as valid 'in our specialised world' (Hocking et al. 2015, p. 31). These different ways of understanding have been metaphorically described as different lenses, dimensions or doorways into the richness of the context being studied. Drawing on this literature we utilize five epistemic lenses to view the changes in socio-material assemblages from multiple perspectives. Each lens sheds a different light on each of the shifts.

Our lenses are:

- **The biophysical lens**, which has a focus on measurement, is a familiar form of understanding in academia. It describes the things we can see, feel, touch, hear and taste. It includes space, time and things.
- **The cultural lens** includes the assumptions, practices, understandings and expectations that we share with the various communities we are part of, and which may not be accessible to those from other groups.

- **The ethical (or values-related) lens** includes ideals, values, interests, principles, and standards.
- **The relational lens** is about our connections to the human and nonhuman actors in the system. It also relates to our sense of trust, loyalty, connection, leadership and conflict, and our sense of others.
- **The aesthetic lens** relates to perspectives on beauty and ugliness, on design and visions. It relates to the less tangible factors that contribute to human wellbeing, and other emotions such as happiness, hope, calmness, excitement and contentment. It also relates to the concept of 'enlivenment' (or 'die Lebendigkeit' as it was originally conceived in German), where humans seek to reconnect to their aliveness and creativity (and that of the world) and through the enlarged understanding of art as expressed by the artist Joseph Beuys, who proposed that every human being is an artist (Weber and Kurt 2015).

Using this multidimensional set of lenses helps us to examine the richness of the sociomaterial assemblages as a complex, interrelated whole. The dimensions do not define sociomateriality, but provide a framework within which to examine and learn about the assemblages under study. A multidimensional understanding also supports the co-creation of new ways of thinking, learning and acting to work with the complexity and diversity of the systems we are trying to adapt (in this case the classroom).

11.5 Making the Shift

Our experience of making the shift towards transdisciplinarity is similar to that of others in this book, and we refer the reader to explore other chapters for a deeper examination of the theoretical underpinnings of the concepts involved. Our choice of shifts also reflects a movement from deep, underlying (and often tacit) theoretical considerations, upward towards the more visible and physical aspects of learning spaces.

11.5.1 The Shift from a Disciplinary Foundation to a Problem Focus

Traditional higher education pedagogy has relied on transmitting disciplinary knowledge to students, with a focus on establishing an acceptable level of knowledge and understanding (McGregor 2017). Transdisciplinary pedagogy, on the other hand, focuses on the problem at hand, and on bringing to bear a broad spectrum of knowledge and understanding with which to tackle these problems. This is particularly so in the case of complex and wicked problems.

One hallmark of transdisciplinary research has been a shift in focus from narrow, disciplinary content concerns to a 'problem-based focus, an interest in action, participatory approaches' (Klein 2017, p. 10) and the tackling of 'wicked', 'real-world' problems (Gaziulusoy and Boyle 2013; Klein 2018, Chap. 2 in this book). A wicked problem is a complex problem that defies complete definition, and for which there can be no final solution, since any resolution creates further problems, and solutions are not true or false or good or bad, but the best that can be done at the time (Brown 2010, p. 4). This requires a significant shift in the form of learning that the problem-solver is likely to experience. Gardner (1991) describes this shift as a move from the traditional, scholastic learner to the person who is more broadly experientially skilled as well as being an expert.

This shift can create dissonance and confusion for some students, particularly those who are used to structured, discipline-based information gathering for exams later in the semester. These students expect certain content areas to be covered and flagged as important. In contrast, a problem focus encourages a collaborative exploration of the complexities surrounding the problem. This requires the students to create partnerships with each other and develop listening and synthesis skills. As a result, a strong connection develops between the students and the problem framing they are focusing on. For example, in our discussions about the complex challenges of the anthropocene, we engaged the students in discussions about a range of issues that connected strongly to the students' experiences, for example, promoting the use of bamboo baskets rather than plastic bags, waste disposal in urban environments in different countries, energy sources and use across multiple cultures and landscapes.

In attempting to shift our pedagogy to align with this shift in focus, we have designed and experimented with different unit structures and activities. For example, we have used the current popularity and profile of games such as PokemonGo to illustrate the ways in which the affordances of the ubiquitous smartphone are significantly changing the way we relate to each other, and to our physical environment.

From a cultural perspective, our approaches necessarily move outside the usual protocols and expectations of disciplinary teaching. Because our classes included such a diverse range of cultural backgrounds (in all senses of the word), we used small group work and feedback sessions to enable students to share their perspectives, experiences and problem framings. In this way, we encouraged them to become increasingly self-organizing learners drawing on a wide range of learning experiences, both within and beyond the confines of the university.

Most importantly, from the aesthetic perspective, we focused on making the learning journey enjoyable and memorable. We focused on images and representations that the students could relate to—for example we based one session around the film *The Matrix.* We used the metaphors and story of the film to examine ontological and epistemological framing and the importance of tacit knowledge. We also introduced rich picturing and concept mapping to create visual representations and encourage the students to think collectively and creatively.

11.5.2 The Shift from a Unified, Hegemonic Approach to Foundational Thinking to Embracing a Diverse, Inclusive Plurality of World-Views

The most challenging shift is a fundamental one. Put simply, the shift towards transdisciplinary thinking requires paradigmatic change. The shift from traditional to transdisciplinary approaches is a shift from a disciplinary focus (or focus on expertise) to a focus that is primarily on societal problems and complex systems. These problems are highly complex, change rapidly, have no simple or single solutions and are perceived differently by different people. In response, transdisciplinary teaching is shifting from a focus on creating disciplinary expertise to focusing on understanding and learning to tackle these problems using a range of academic and practice-based skills and experiences.

This shift also includes a move from a hierarchical and hegemonic way of thinking and acting towards a greater plurality of ontological and epistemological framings and towards understanding the world as a 'meshwork of mutually transformative and meaningful relationships' (Weber and Kurt 2015). The change in foundational thinking is the most difficult kind of change, and can be considered a deep leverage point in the process of change towards tackling the wicked problems of the Anthropocene (Abson et al. 2017; Meadows 1999).

One of the biggest challenges for the students was the loss of the certainty of right and wrong answers. Instead they were presented with uncertainty and ambiguity and a move away from the idea that scientific knowledge is somehow 'better' than other ways of knowing, to the idea that all knowledge is partial, plural and provisional, and that generating knowledge requires many auxiliary assumptions and is context dependent (Russell 2010).

In studying rural sustainability in the Murray-Darling Basin (in Australia's south-east), we introduced the geography of the area through the Annales historians, examining the various layers of the Annales, including geography, geomorphology, sociology and particular events. We then added to the systems thinking, the framing of wicked problems and biophysical and ecological settings. During the field trip and guest lectures, we introduced the students to a range of different perspectives and approaches to land management, and encouraged them to engage with a plurality of views, including amongst themselves. As lecturers, we deliberately disagreed with each other on certain points (on the basis of our different disciplinary backgrounds and our varied and extensive life experience). We also did not expect to be always right. We used this as a means of departing from the traditional knowledge hierarchy in which the lecturer transfers knowledge to the student.

11.5.3 The Shift from Compartmentalization of Knowledge to Knowledge Co-production As a Human and Social Process

The third shift follows on from the second shift in foundational thinking, in that it is about a change in how we view knowledge (epistemology) and what we believe about what exists in the world and the nature of human beings in the world (ontology). For example, in the case of many of the natural sciences, the third shift includes a shift from a linear, reductionist, instrumental approach to research and learning, towards a more collective, reflective, reflexive approach that encompasses iterative process and positive engagement with tension as both constructive and creative. It also includes the addition of some of the contrasting paradigms and pedagogies of the humanities, arts and design; and it involves bringing together previously separated disciplines such as geography and history.

One aspect of this type of change is a shift in legitimacies (Tost 2011). In particular, it has raised questions about what is legitimate knowledge and who can legitimately be involved in its generation. Therefore, transdisciplinary pedagogy should reflect a more open and inclusive participation by all (but does not infer an ‘anything goes’ mode of operation). It implies a reduction in power asymmetries to allow for the inclusion of different worldviews or ways of understanding the content of the unit. This brings our ethical, values-related epistemic lens to the fore.

The shift in legitimacy is directly linked to changes in the patterns of social interaction which emphasize the relational lens. Transdisciplinary research into wicked problems has usually been linked to some form of participation and collaboration, either between different disciplinary experts, or amongst all the different knowledge cultures engaged in tackling the problem (Brown 2008). This entails a shift from individualistic, homogenous activity to collective heterogeneous activities and associated social interactions. The shift in the socialities of research also impacts on the status and privileged positions of disciplines and academics. Virtually all the chapters in this volume address this issue, and it is reflected in the book’s title, in which the word ‘collaborative’ implies some form of equality among those involved. In this section, we describe how we responded and adapted to the shifts in legitimacies and socialities in our undergraduate and postgraduate units.

The authors’ professional relationship goes back decades, and we have worked collaboratively for all that time. Initially, our roles were client and consultant, but from the first those roles were blurred, and every aspect of the design and application of organizational interventions was undertaken together in a close dialogue of equals. Consequently, we brought this collaborative approach to our joint teaching in more recent years. Our years of experience of collaboration also mean that much of our thinking has become normalized and tacit. We extended this to the tutors who joined us in the teaching team. They initially found this approach novel and challenging, but also empowering. This created a very positive team atmosphere with greater creativity and mutual support.

Part of our collaborative design was to create spaces for emergent ideas and activities, generated from our interactions with the students to create a collective learning environment. Therefore for us, collective learning occurs not just between the students, but also between us and the students. In particular, we allowed doubt and questioning through peer group interactions in order to elicit responses to a problem or concern. We did not attempt to constrain responses or predict all the ideas that might be generated. Therefore, we were often faced with new information that was not included in our original design.

This initially created a gap between more traditional expectations and the shift in approach. For example, some students interpreted this approach as being underprepared, which created a sense of unease regarding our legitimacy as experts. This was amplified when we deliberately disagreed with each other on a particular point, emphasizing our different disciplinary backgrounds. While some students felt we should have "worked out our differences before coming to teach the topic", most found these disagreements entertaining and informative, and they gained an immediate insight into some of the contestations which are common between disciplinary fields. Finally, we invited students to disagree with us and present their own coherent arguments. We asked genuine questions of them and incorporated their answers into what we did next. This generally resulted in much greater coherence and vigour in our discussions.

This approach was generally in conflict with many of the tacit expectations about how learning activities should function, particularly for some of the older students whose memories of university were of a more traditional pedagogy. It is often assumed that the more senior an academic, the more knowledge and expertise and therefore status and respect they deserve. This creates a cultural hierarchy that places tutors on a lower rung and students a number of rungs below that. This legitimizes the knowledge of some over others and is amplified by the set-up of physical learning spaces.

As each unit progressed the majority of students came to enjoy the new social structure we had developed. One feature of the improved relationality was an increase in trust (Robbins 2016). We in turn learnt from the feedback from, and dialogue with, the students and tutors and with every repeat of a unit we redesigned and further developed our approach.

For us, a significant part of the early teaching period in each unit was a focus on building a picture of the group, and working to create a socially coherent learning environment. At the beginning of each semester, we engaged with the students in a mutual attempt to understand who we were as people and learners. What were the backgrounds, interests, motivations and values of those in the unit? What prompted them to enrol in the course? What expectations did they have? Using our epistemic lenses, we also enquired about their cultural backgrounds. Many of our students were international, coming from a wide range of countries and backgrounds. Cultural groupings also included different age groups (ranging from late teen undergraduates to mature age master's students with extensive life and career experience).

Generally, our units included a four-day field trip. This not only provided a lived-experience approach to learning, it also allowed for building of relationships and connections between the students, encouraged by the need to work in groups. While during the day we visited farms, factories, environmental parks and facilities, in the evenings we mixed social interaction with feedback and discussion sessions. Staff and students stayed in bunkhouse accommodation and shared cooking and cleaning and evening social activities.

11.5.4 The Shift from Traditional Uses of Space and Time to New More Flexible and Dynamic Arrangements

Our final shift is the most visible and the one where we faced the most obvious constraints. It encompasses changes in the use of time, space, things and technologies. In our teaching units we attempted to amplify and embed the shifts in focus, knowledge and relationships through our use of the available material elements. So, in shifting materialities, we would describe our adapted pedagogy as making flexible arrangements of time, space and things. While this is not necessarily specific to transdisciplinary pedagogy, we argue that it becomes more urgent and essential in the transdisciplinary teaching context.

Time is one of the most tacit elements in a university. From the moment a student enrols, time is divided into predictable patterns of lectures, tutorials, workshops and field trips. Life is subject to the rhythms of study, assessment and holidays. The administrative default setting for our units was an expectation of a 1-h lecture and a separate 2-h tutorial (often with multiple tutorial groups if the class was large) spread throughout the semester. In our case, we requested a weekly, single block of 3 h. This enabled us to break the time into short periods of monologue, dialogue, panel sessions and workshops, thus adding diversity to traditional formats. This was often in conflict with the expectations of many students who (under a more traditional format) often skip lectures and only come for tutorials. This was exacerbated by multiple timetable clashes between subjects. While we had limited agency to adapt to this, we responded by trying to include as much material as possible on the Moodle website (the e-learning online tool used by our university).

Along with the timeframes, we inherited both the spaces for learning and the furniture and technologies within them. A significant issue we experienced was the allocation of rooms at the beginning of the semester. In our case, for two semesters we were allocated a room quite late, well after other courses. This limited our choice, and resulted in spaces that were often suboptimal for the class size and difficult to utilize in a transdisciplinary manner.

A shift to a more transdisciplinary approach to learning requires a rethinking of even our most fundamental assumptions about learning spaces. Let's start with a seemingly simple question: what is a classroom? Reflecting on this question can bring to the surface many (often unconscious) assumptions held about learning and teaching. It can also help us understand how the setting for learning and research affects us as educators and students. The term 'classroom' is a very common description of tertiary teaching spaces. We contrast this with the German term for a teaching space: 'der Hörsaal' which literally translated combines the nouns for 'hearing', and 'room' or 'salon', reinforcing the Medieval idea of students receiving or hearing the wisdom of their teachers (Mulcahy et al. 2015).

At our university (a relatively modern one), most of the teaching rooms are separate and enclosed, with lockable doors. Furniture in the rooms usually consists of a projector directed at a fixed screen on one wall for presenting, and chairs and/or desks, usually set out in rows facing the front, sometimes fixed in tiers, sometimes moveable. This layout reflects the historical origins of universities. Traditional university rooms are based on the medieval catholic mass. They reflect a hierarchy of 'lecturer' (reader) over the students (writers) as the knowledge is passed from the former to the latter (Park and Choi 2014, p. 750). After World War II, modernist architecture, based on efficiency, allowed greater numbers to fit in 'lecture' halls to have knowledge transmitted to them in a one-way flow (Dovey and Fisher 2014, p. 44).

In contrast to many universities, various high schools have been built with a design for 'open plan' classrooms where multiple classes share a single space. These buildings reflect a period in the 1970s of "architectural innovation linked to new pedagogies" (Mulcahy, et al. 2015), based on 'constructivist' ontologies and epistemologies. So the shift in school learning space design reflects the shift in pedagogical philosophy:

> In this new constructivist thinking, where teachers serve as facilitators for active student engagement, where learning occurs in many locations, and where power is distributed across actors, learning space needs are seen to be far more dynamic and situational than they were under the transmission model. (Van Note Chism 2002, p. 10)

Learning spaces, then, can be seen as sociomaterial assemblages that enable and constrain different forms of interaction (Van Note Chism (2002) where the physical space is not neutral but has been designed for a particular form of learning. However, the original design and intent does not completely determine the uses to which these spaces are put, and we were able to adapt our inherited sociomaterial assemblages by reassembling the elements we could change in new ways. One way of adapting was by considering the 'affordances' of what we had to work with. Affordances are described as:

> the physical properties of an object [that] make possible different functions for the person perceiving or using that object. In other words, the properties of objects determine the possibilities for action. (Dovey and Fisher 2014, p. 44)

The combined experience of the authors as educators ranging from kindergarten to postgraduate level teaching, as well as adult education, and it includes a host of different educational settings. In many cases we have had little choice about the place allocated to us for our learning activities. Usually we have had to operate in a standard 'classroom' or university 'lecture theatre' or 'seminar room'. Beyond these more standard settings we have also 'taught' in massive halls, small hotel rooms, tin sheds, hallways, buses (see prologue), outdoor school benches, hilltops, paddocks, fields, swamps, orchards, company boardrooms, top-secret facilities, shearing sheds, airport lounges, shacks, huts, and (our personal favourite) floating down a river on home-made rafts. Each has brought with it both constraints and affordances for different types of learning. Each is also situated within a larger temporal and spatial environment, with its own affordances and constraints.

Along with other objects, the affordances of technologies constrain and enable what is possible in a learning environment. In our case we have focused on technologies that support dialogue (Sellen and Harper 2003). These have included those things often found in university rooms such as whiteboards and projectors, but we have also used some things in less traditional ways. Windows have thus became places for post-it note brainstorming in small groups (p. 17) and whiteboards have become 'boundary objects' (Bohm 1996; Conklin 2005; Isaacs 1999) for students to explore and co-create ideas.

We have also introduced new technologies, including cameras on field trips and 'keypads' or 'clickers', a form of personal, anonymous, instant surveying technology that supported our early semester 'getting to know each other' activities. Another interesting development in technology has been the introduction of online tools for learning. In our case, the university uses the Moodle website, where readings, lecture notes, lecture recordings, assignments, and other resources are stored.

Finally, field trips contain many material affordances for time, space and things. For example, buses became relational, social spaces that supported the building of trust and offer opportunities for deep dialogue (Straker 1997). Which brings us back to our prologue and the buses (Fig. 11.1).

Fig. 11.1 Ever on the move: field trip buses as a prime example of adaptive sociomaterial assemblages for collective learning. (Photo by Craig Ashhurst 2011)

11.6 Conclusion: Reflecting, Dealing with Tension and the Next Cycle of Learning

In this chapter, we have outlined our approach to adapting the learning spaces we inherited. Our description of this approach has been presented under four key shifts: disciplinary to problem focus; from a unified, hegemonic approach to foundational thinking to embracing a diverse, inclusive plurality of world-views; compartmentalization to co-production of knowledge; and the shift away from traditional uses of space, time and things. To address and work with complexity, we used multiple perspectives to understand and adapt these learning spaces by using five epistemic lenses (biophysical, cultural, ethical, relational and aesthetic).

The process of change and the variations in the pace at which various elements change create incoherences, uncertainty and tension between conflicting realities. Dealing with this requires the adoption of additional principles of reflection and reflexivity, a willingness to engage positively with tension and incoherence, and an iterative approach to adaptation that should also be transparent to the students.

This process of adaptation within complexity and of tackling wicked problems is a key part of the learning for students of transdisciplinarity. Therefore, we have been transparent about the realities of change, particularly in the Anthropocene. In many cases, the rhetoric of transdisciplinary teaching lags behind the reality. If the teaching approach used is based on disciplinarity and content-focused individualistic learning, it doesn't matter how innovative the teaching space is, it can still lead to a sense of pedagogical incoherence for the students where there is a lack of correspondence between the lived experience of learning and the expectations and theoretical framing. Like the buses in our prologue, there is constant movement and change, which is incorporated into the transdisciplinary learning experience, and teachers and students become fellow adaptive travellers in our rapidly changing world.

Acknowledgements The authors would like to gratefully acknowledge the many different contributions to our thinking for this chapter, particularly our many students for their enquiring minds and willingness to embark on the transdisciplinary journey in our teaching modules. To all those who have shown us that there are multiple ways of understanding, particularly Professor Emerita Valerie Brown and her frequent co-author Dr. John Harris. Finally thank you to those who have provided critique of our ideas and writing, especially our writing group and Pip Ashhurst who kindly edited the drafts.

References

Abson, D. J., Fischer, J., Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., et al. (2017). Leverage points for sustainability transformation. *Ambio, 46*(1), 30–39. https://doi.org/10.1007/s13280-016-0800-y.

Bohm, D. (1996). *On dialogue*. New York: Routledge.

Brown, V. A. (2008). *Leonardo's vision: A guide to collective thinking and action*. Rotterdam: Sense Publishers.

Brown, V. A. (2010). Collective inquiry and its wicked problems. In V. A. Brown, J. A. Harris, & J. Russell (Eds.), *Tackling wicked problems: Through the transdisciplinary imagination* (pp. 1–13). London: Earthscan.

Brown, V. A., & Harris, J. (2014). *The human capacity for transformational change: Harnessing the collective mind*. New York: Routledge.

Clarke, E. A. (2016). *The synergies of difference: Strengthening transdisciplinary research practice through a relational methodology*. Canberra: The Australian National University.

Conklin, J. (2005). *Dialogue mapping: Building shared understanding of wicked problems*. Hoboken: Wiley.

Dovey, K., & Fisher, K. (2014). Designing for adaptation: The school as socio-spatial assemblage. *The Journal of Architecture, 19*(1), 43. https://doi.org/10.1080/13602365.2014.882376.

Fenwick, T., Edwards, R., & Sawchuk, P. (2011). *Emerging approaches to educational research: Tracing the sociomaterial*. London: Routledge.

Gardner, H. (1991). *The unschooled mind: How children think and how schools should teach*. New York: Basic Books Inc.

Gaziulusoy, A. I., & Boyle, C. (2013). Proposing a heuristic reflective tool for reviewing literature in transdisciplinary research for sustainability. *Journal of Cleaner Production, 48*, 139–147. https://doi.org/10.1016/j.jclepro.2012.04.013.

Hocking, V. T., Brown, V. A., & Harris, J. A. (2015). Tackling wicked problems through collective design. *Intelligent Buildings International, 8*(1), 24–36. https://doi.org/10.1080/17508975.2015.1058743.

Isaacs, W. (1999). *Dialogue and the art of thinking together: A pioneering approach to communicating in business and in life*. New York: Bantam Doubleday Dell Publishing Group.

Kaplan, A. M., & Haenlein, M. (2016). Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Business Horizons, 59*(4), 441–450. https://doi.org/10.1016/j.bushor.2016.03.008.

Klein, J. T. (2017). Transdisciplinarity and sustainability: Patterns of definition. In D. Fam, J. Palmer, C. Riedy, & C. Mitchell (Eds.), *Transdisciplinary research and practice for sustainability outcomes*. London/New York: Routledge.

Klein, J. T. (2018). Learning and transdisciplinary collaboration: A conceptual vocabulary. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

McGregor, S. (2017). Transdisciplinary pedagogy in higher education: Transdisciplinary learning, learning cycles and habits of mind. In P. Gibbs (Ed.), *Transdisciplinary higher education: A theoretical basis revealed in practice* (p. 3015). London: Springer.

Meadows, D. (1999). *Leverage points: Places to intervene in a system*. Hartland: The Sustainability Institute.

Mulcahy, D., Cleveland, B., & Aberton, H. (2015). Learning spaces and pedagogic change: Envisioned, enacted and experienced. *Pedagogy, Culture & Society, 23*(4), 575–595. https://doi.org/10.1080/14681366.2015.1055128.

Orlikowski, W. J. (2007). Sociomaterial practices: Exploring technology at work. *Organization Studies, 28*(9), 1435–1448.

Park, E. L., & Choi, B. K. (2014). Transformation of classroom spaces: Traditional versus active learning classroom in colleges. *Higher Education, 68*(5), 749. https://doi.org/10.1007/s10734-014-9742-0.

Prior, J., Cuzac, C., & Capon, A. (2018). The role of pliability and transversality within trans/disciplinarity: Opening university research and learning to planetary health. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Robbins, B. G. (2016). From the general to the specific: How social trust motivates relational trust. *Social Science Research, 55*, 16–30. https://doi.org/10.1016/j.ssresearch.2015.09.004.

Ross, K., & Mitchell, C. (2018). Chapter 4: Transforming transdisciplinarity: An expansion of strong transdisciplinarity and its centrality in enabling effective collaboration. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education* (pp. x–xx). Dordrecht: Springer.

Russell, J. (2010). A philosophical framework for an open and critical transdisciplinary inquiry. In V. A. Brown, J. A. Harris, & J. Russell (Eds.), *Tackling wicked problems: Through the transdisciplinary imagination* (pp. 31–60). London: Earthscan.

Sellen, A. J., & Harper, R. H. R. (2003). *The myth of the paperless office*. Cambridge, MA: MIT Press.

Straker, D. (1997). *Rapid problem solving with post-it notes*. Hampshire: Gower Publishing.

Tost, L. P. (2011). An integrative model of legitimacy judgments. *Academy of Management Review, 36*(4), 686–710. https://doi.org/10.5465/amr.2010.0227.

Van Note Chism, N. (2002). A tale of two classrooms. *New Directions for Teaching and Learning, 2002*(92), 5–12. https://doi.org/10.1002/tl.74.

Weber, A., & Kurt, H. (2015). Towards cultures of aliveness: Politics and poetics in a postdualistic age, an Anthropocene manifesto. *Solutions*, September–October 2015.

Chapter 12
Making the Link Between Transdisciplinary Learning and Research

BinBin Pearce, Carolina Adler, Lisette Senn, Pius Krütli, Michael Stauffacher, and Christian Pohl

12.1 Introduction

Transdisciplinarity (TD) is a chameleonic concept within academia. Two strands of thought, however, have crystallized. One strand sees transdisciplinarity as scientific inquiry that resists reductionist and mechanistic explanations of reality and acknowledges the potential for co-existence of different realities (Nicolescu 2010; Klein 2017). This idea of transdisciplinarity includes an intention to build bridges between different ways of thinking and seeing. A second strand sees transdisciplinarity as scientific inquiry whose motivation stems from a need to address real-world, wicked problems (Rittel and Webber 1973) or complex problems. This approach is characterized by the framing, analyzing and solving of these problems *together* with non-academic actors (Hirsch Hadorn et al. 2006; Pohl et al. 2007). A concept like transdisciplinarity has emerged out of a need to deal with a growing complexity of problems in society and changing expectations for science in society. Such a need is especially apparent in the field of environmental science, where sustainability and other normative concepts of how society should develop in the future are in question. Both the challenge and potential of transdisciplinarity lie in its varied facets. Clarity is of utmost importance, however, when students are expected to learn and experience what transdisciplinarity is. The following paper is a reflection on how we have chosen to define this concept.

Transdisciplinary learning (TD learning) refers to both the condition of learning *in* a transdisciplinary setting and learning *about* transdisciplinarity, including the methods and assumptions that researchers take on when carrying out transdisciplinary research. In this chapter, we present an approach to TD learning developed

B. Pearce (✉) · C. Adler · L. Senn · P. Krütli · M. Stauffacher · C. Pohl
Department of Environmental Systems Science, Transdisciplinarity Lab, ETH Zurich, Zurich, Switzerland
e-mail: bin.pearce@usys.ethz.ch

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_12

for courses at the Transdisciplinarity Lab (TdLab) in the Department of Environmental Systems Science at the ETH Zurich in Switzerland. These courses were not designed in a one-off process. Rather, they evolved over time through the contributions of various TdLab members and by assessing students' reactions to the course material. However, this chapter represents our attempt to make explicit our mental model of teaching and learning such that we are able to build upon this understanding in future courses.

12.2 The Transdisciplinarity Lab (TdLab)

The TdLab is a group of professors, lecturers, researchers, and graduate students working with and for society on issues of sustainable development. This group is responsible for teaching and research across disciplinary and sectoral boundaries. Seven core courses spanning bachelor's, master's, and PhD levels are taught each year, not including additional short-term, extracurricular summer and winter schools. TdLab is the platform for several ongoing transdisciplinary research projects in the areas of energy infrastructure, sustainable practices, communication of the uncertainties of climate change, public health, transdisciplinary methods and teaching methodology. Our approach to TD learning is to design and implement courses that equip students with the capacity to be effective in the field of sustainable development, either within a research or practice context.

We take Meeth's definition of transdisciplinary learning (Meeth 1978, p. 173) as our starting point: "Whereas interdisciplinary programs start with the discipline, transdisciplinary programs start with the issue or problem and, through the processes of problem solving, bring to bear the knowledge of these disciplines that contributes to a solution or resolution." A key approach directing our teaching is that the students frame the problem, along with non-academic actors who have an interested in the problem, always adapting to an evolving understanding of system under study. The problem is therefore not given beforehand. In terms of developing a solution, we mean that it is a strategy or measure in the realm of sustainable development that is able to effectively bring science and society together through an agreed-upon identification of the problem.

According to ProClim (1997), there are three main needs that science can fulfill for society in this process of problem framing and solving. The first need is for the knowledge of "what is": how environmental systems function, how the parts of the system relate to one another and how such a system can be assessed. This is referred to as systems knowledge. The second need is for knowledge of "what should be": what are goals that society should set in order to create an improved or transformed system. This is referred to as target knowledge. The third need is for knowledge of "how we get there": How does society transition or transform from the current state to the target state? Which strategies should we adopt to get to where we want to go? These three levels of knowledge are interconnected and build upon one another. TD learning aims to equip students with the capacity to acquire, distinguish between and effectively engage with all three levels of knowledge, so that students will be better prepared to contribute to societal transformation in policy, research or another setting in the future.

We have so far set the stage for understanding TD learning, then, as developing students' ability to create and apply systems, target, and transform knowledge, with the aim of being able to engage with wicked problems related to sustainable development. There are two key consequences of this way of framing TD learning.

First, because TD knowledge can be applied to research, policy or other types of real-world endeavours, we aim to provide students with diverse conduits through which to gain TD knowledge: through academic contexts, but also through direct contact with non-academic stakeholders. The deliverables that students produce are not only scientific writing and research, but also prototypes of products or processes that are testable with stakeholders. They may also include communication that is aimed at the broader public (e.g. newspaper articles, videos, etc.).

Second, by taking the stance that target and transformation knowledge are as scientifically valid as systems knowledge, we are expanding the definition of scientific knowledge in TD learning. This represents a paradigm shift, from relying on science to describe and explain phenomenon in the world, to expanding its use for also clarifying societal goals (target knowledge) and how to get to those goals (transformation knowledge). This shift could be described as one of the key differences between the so-called "Mode 1" and "Mode 2" production of knowledge (Gibbons et al. 1994). Within Mode 2 production of knowledge, knowledge is intended to be useful to society, within a "context of application" and continuously negotiated, in contrast to being guided by the "cognitive and social norms of academic science" (Gibbons et al. 1994, p. 4). This key shift is taken up both in TD research, and importantly for this chapter, in TD learning. We will explore these implications in more detail in the following sections.

12.3 Competence Fields

The pursuit of all three types of knowledge, "systems", "target" and "transformation knowledge", provides the justification for the six competence fields that TdLab's courses aim to address. These competence fields describe what we hope students will be able to do once they complete our courses. A **competence field (CF)** contains a set of interconnected **learning objectives** for students. We use these competence fields as the basis for designing didactic approaches tailored to each of the bachelor's-, masters-, and PhD-level courses we will describe in following sections.

In no particular order, these competence fields are:

1. "Communicating values": Students are able to identify, ground and communicate assumptions and normative values in topics related to the concept of sustainable development.

2. “Reflecting about self and others”: Students are reflective about their own perceptions and biases with regards to sustainable development.
3. “Applying concepts in the real-world”: Students are able to appropriately apply conceptual knowledge to specific contexts, and, in parallel, exercise practical skills (such as project organization and time management) to deliver the required end products.
4. “Framing complex problems with others”: Given a real-world topic and its accompanying conflicts and uncertainties, students are able to identify and frame clear, relevant problems with those who have contrasting perspectives or opinions.
5. “Researching in and with the real-world”: Students are able to translate real-world problems into viable research questions. They are also able to identify the adequate research method(s) to investigate these questions and to co-produce knowledge with society.
6. “Imagining solutions and their consequences”: Students are able to explore and develop solutions for real-world problems, while being aware of the possibility of unintended consequences of these solutions and taking responsibility for these consequence.

Wiek et al. (2011) also define a set of “key competences in sustainability”. Rather than placing the concept of TD learning at the center, the ability to solve problems in the field of sustainability is the focus. They define systems thinking, strategic, interpersonal, anticipatory and normative competencies and show how these competencies are connected to an “integrated sustainability research and problem-solving framework”. Both the competencies and the framework were formed through clustering key concepts through a literature review using key terms such as “sustainability”, “higher education”, and “key competencies” and by looking at skills necessary for carrying out methods for complex problem solving in the field of sustainability. Though there are areas of overlap between the competencies that were identified by Wiek et al. and ours, there are also key differences. For example, we emphasise the importance of intra-personal skills (competence field 2), in addition to interpersonal skills. This ability to reflect on self and others is a key piece of Td learning for us, which is not included in Wiek et al. In addition, stand-alone competences in Wieks et al., such as “systems thinking”, “anticipatory”, and “strategic” competences, we have as a part of competence field 6. For us, these tools are means by which to arrive at the goal of being able to imagine solutions and their consequences, and not aims unto themselves. While an in-depth comparison is beyond the scope of this chapter, one is already able to get a sense that the goal of TD learning competences focuses on the development of the individual, and the key competences in sustainability are focuses skills necessary in solving complex problems in the sustainability realm. Intrapersonal and other non-cognitive abilities are brought to the fore in TD learning, which may remain implicit in Wieks et al. The assumption lying at the heart of TD learning is that the individual is the key component to a successful transformation process. This stands in contrast to the assumption that what must be taught in sustainability education is particular structured way

Table 12.1 Competence fields analyzed in reference to learning domains

Competence fields	**Cognitive domain (knowledge)**		**Affective domain (attitudes)**		**Psychomotor domain (skills)**	
	CF Language	Dimension within domain	CF Language	Dimension within domain	CF Language	Dimension within domain
1 Communicating values	Identify/ Ground assumptions Content knowledge of the topic (sustainable development)	Analyze Understand	Identify/ Ground normative values	Value	Communicate assumptions	Articulate
2 Reflecting about self and others	Reflective and aware of own perception and biases	Analyze; Evaluate	Reflective and aware of own perception and biases	Value; Prioritize; Internalize values		
3 Applying concepts in the real-world	Apply conceptual knowledge of environmental sciences to specific contexts	Apply			Exercise practical skills to deliver the required end products	Refine; Articulate
4 Framing complex problems with others	Identify and frame clear, relevant problems Cope with frustration and uncertainty		Analyze; Evaluate Internalize values			
5 Researching with the real-world	Translate real-world problems into research questions Identify appropriate methods for addressing questions		Apply; Evaluate; Prioritize Analyze; Create	Value		
6 Imagining solutions and their consequences	Explore and develop solutions Become aware of solutions' unintended consequences			Apply; Manipulate; Evaluate; Refine; Create; Evaluate	Prioritize; Internalize values; Articulate; Receive phenomena; Respond to phenomena	

Shaded boxes indicate those aspects of the competence fields that include some aspect of the affective learning domain

of problem solving, and seeing the students as the bearers of this way of looking at the world once they are in the world themselves.

In Table 12.1, the CFs above are deconstructed into individual learning objectives. Each learning objective, in the form of a phrase, is then matched to a learning domain and a learning dimension within that domain, as originally defined by Bloom (1956) and later updated by Anderson et al. (2001). This taxonomy describes three learning domains: the cognitive, affective, and the psychomotor. The cognitive domain is defined by the acquisition of knowledge and intellectual abilities. The affective domain is defined by the perception, response and prioritization of values, emotions and motivations. The psychomotor domain includes the acquisition of physical skills that come from experience and practice, in contrast to abstract thought (broadly described by Bloom 1956; later refined by Dave 1975). These learning domains can be further divided into **learning dimensions**,[1] which define the specific actions associated with these domains. By linking the competence fields to these learning dimensions, we are able to define TD learning as a balance of skills between these different domains.

Table 12.1 reveals three main insights about the competence fields. First, each of the competence fields can be deconstructed into multiple learning objectives. Each of these learning objectives corresponds to a specific learning dimension, as explained above. This correspondence serves as the basis for determining which learning domain(s) are included within a competence field. Second, each competence field crosses into at least two learning domains. The learning domains are therefore interconnected in our courses. Affective learning objectives engage cognitive skills and vice versa. For example, ensuring that students are able to "identify and ground assumptions" is an objective that straddles the cognitive and affective domains, and it requires students to both understand and analyses (cognitive domain skills) *and* to value the information they receive (affective domain skill). In fact, three of the six competence fields incorporate all three learning domains. The third insight is that the affective learning domain plays a major role in our teaching. Each competence field contains at least one learning objective that can be categorized in that domain. This emphasis on affective skills is an important link between learning about transdisciplinarity as a student and implementing transdisciplinary projects, a point we will develop later in the chapter. Stokols (2014) also identifies values, attitudes and beliefs that promote a transdisciplinary intellectual orientation. This collection of attributes is what we would consider to belong in the affective domain.

12.4 Competence Fields at Work

In this section, we look at how these competence fields are applied to three of the seven TdLab courses. We have chosen one course to represent each of the bachelor's, master's and PhD study programmes (See Table 12.2).

The bachelor's-level course is a year-long, compulsory course for first-year students in the Department of Environmental Systems Science at ETH Zurich. The focus is on introducing students to the analysis of environmental systems and on fostering critical thinking and creative capabilities by requiring students to design solutions to complex problems related to sustainable development topics in Switzerland. The topic changes each year (e.g. public transportation, the gravel system, wind energy, re-use and cycling in the construction industry etc.). A group of stakeholders,

[1] Table 12.4 contains a complete list of these dimensions for each learning domain.

Table 12.2 List of TdLab courses

Course level	Course title	Course type	Duration	ECTS[a]	Interdisciplinary cohort?	Group work required?
Bachelor	Tackling environmental problems	Compulsory	Year-long	10	N	Y
Master	Transdisciplinary case study	Elective	Semester	7	Y	Y
PhD	"Science meets practice"	Winter School	8 days	4	Y	Y

[a]Total work load = European Credit Transfer and Accumulation System credit points * 30 h/credit point

as well as tutors, who are past students of the course, help the lecturers decide on the framing of the topic each year. During the first semester, students produce a scientific report and literature review based on a particular theme within the topic (e.g. economics, material flow analysis, law, etc.). In the second semester, students identify a specific problem based on their understanding of the topic and develop solutions accordingly. They build prototypes of the solutions and present them to the stakeholders, lecturers and one another at the end of the second semester.

The Transdisciplinary Case Study is a semester-long course that serves as the cornerstone of a three-course "Transdisciplinarity for Sustainable Development" minor for master's students. The case study belongs to either the Environmental Sciences or Agricultural Sciences areas within the department. The goal of the course is provide students hands-on experience in designing and carrying out a transdisciplinary research project. The topic alternates between a locally-based Swiss case study and an international case study year to year. (In recent years, we have had a long-standing collaboration with the government and university in the Seychelles).

The TdLab "Science meets Practice" Winter School is an eight-day, extracurricular course designed for PhD and postdocs and is held during the winter holidays every year. It provides a setting for those embarking on a journey towards becoming independent researchers. It enables them to reflect upon and to reconsider their roles as scientists in society, and what relevance their work might have for society. Coached by experienced TD researchers, participants learn to "do" TD research through listening to stories and building personal experience. In a small town in Switzerland, participants from all over the world engage with residents in the village in an attempt to frame problems and learn from each other, using stakeholder engagement, facilitation, and other transdisciplinary methods and tools.[2]

In Table 12.3, we show how the learning objectives build upon the competence fields. While a competence field can be a shared goal between two or more courses, the way in which that goal is reached varies according to the level of the course. For

[2]Many of these tools can be found on the website of td-net, a Swiss-wide organization supporting transdisciplinary research (https://naturalsciences.ch/topics/co-producing_knowledge/methods).

Table 12.3 Learning objectives for each course corresponding to competence fields

	Courses		
Competence fields	BSc	MSc	PhD
1. Communicating values	**BSc students are trained to communicate values…**	**MSc students are trained to communicate values…**	**PhD students are trained to communicate values** by reflecting on and evaluating scientific projects with respect to their societal embedding, relevance, and consequences.
	…through writing a literature review that complies with scientific standards, such that it adequately summarizes existing knowledge.	…by being confronted with different worldviews and perspectives of stakeholders.	
	…by constructing a conceptual model that reflects their understanding of reality, which includes identifying the boundary, major influencing factors variables and feedback loops in a system.	…by having to engage with diverse perspectives through joint problem framing.	
2. Reflecting about self and others	**BSc students are trained to reflect about themselves and others** by documenting the group working process in a learning journal throughout the duration of the course.	**MSc students are trained to reflect about themselves and others…**	**PhD students are trained to reflect about themselves and others…**
		…while understanding a case and its context from a variety of perspectives, through writing a scientific report and engaging with stakeholders.	…by understanding and critically analyzing foundations of scientific thinking as well as societal implications of research results and innovations.
		…by extracting multiple ways of framing.	…by reflecting on and evaluating scientific projects with respect to their societal embedding, relevance, and consequences.
		…by engaging with stakeholders.	
3. Applying concepts to the real-world	**BSc students are trained to apply concepts to the real-world…**	**MSc students are trained to apply concepts to the real-world…**	**PhD students are trained to apply concepts to the real-world** by being responsible for selecting and applying tools for strengthening a dialogue and interaction with stakeholders.
	…by structuring and organizing effective meetings with stakeholders and experts.	…by being responsible for selecting and applying tools/methods to collect, analyses, and interpret data to answer research questions.	
	…clearly communicating their ideas to a broad audience of stakeholders and experts.	…while working in cross-disciplinary teams.	

4. Framing complex problems with others	**BSc students are trained to frame complex problems with others** by building upon primary and secondary research, through establishing contact with stakeholders and experts, and through prototyping.	**MSc students are trained to frame complex problems with others…**	**PhD students are trained to frame complex problems with others…**
		…by developing research questions that respond to different perspectives and knowledge needs of stakeholders.	…by understanding and critically analyzing foundations of scientific thinking as well as societal implications of research results and innovations.
		…by writing a scientific report.	…by reflecting on and evaluating scientific projects with respect to their societal embedding, relevance, and consequences;
			…by being responsible for selecting and applying adequate tools for strengthening a dialogue and interaction with stakeholders.
5. Researching in and with the real-world		**MSc students are trained to do research in and with the real-world…**	**PhD students are trained to do research in and with the real-world** by being responsible for selecting and applying adequate tools for strengthening a dialogue and interaction with stakeholders.
		…by planning and carrying out their research in the context of a complex sustainability problem.	
		…by being responsible for selecting and applying adequate tools/methods to collect, analyses, and interpret data to answer research questions.	
6. Imagining solutions and their consequences	**BSc students are trained to imagine solutions and their consequences** through iterative brainstorming, prototyping and group discussions and while being aware of the possibility of unintended consequences of these solutions.		

example, competence field 3, “Applying concepts to the real-world”, is fulfilled through various means of stakeholder engagement in the bachelor’s course, while it is done in the context of implementing transdisciplinary research in the master’s course. Competence fields 1, 2, 3, and 4 are common to all three courses. These competence fields, “Reflecting about self and others”, “Applying concepts to the real world”, “Framing complex problems with others”, respectively, form the core of TD learning from our group’s perspective.

The bachelor’s course singularly addresses competence field 6, “Imagining solutions and their consequences”. Students are expected to develop prototypes and solutions to problems they themselves have framed. The master’s case study might also include prototyping exercises, depending on the specific theme that year, but it is not a main focus.

The master’s course is the main course that takes on competence field 5, “Researching in and with the real-world”. Students are expected to translate different understandings of societal problems into concrete research questions. The master’s course has the explicit goal of training students for further scientific work and thus this competence field matches this stage of education particularly well. The Winter School addresses this competence field by giving PhD students an opportunity to apply tools of stakeholder engagement in a workshop format. However, unlike in the master’s course, no research results are collected in the process.

As mentioned earlier, competence fields 1, 2, 3, and 4 are common to all courses at TdLab. We now delve more deeply to explore what these fields are. Competence field 1, “Communicating values” represents a core aspect of TD learning for TdLab. In the bachelor’s course, students practice this communication by making clear what their assumptions are, both through writing scientific reports, and by building qualitative systems models. For these students, assumptions and normative values are clarified through specific tasks, such as writing and building models, rather than drawn out through discussions alone. For master’s students, the communication of assumptions and values occurs when they interact with stakeholders during a problem framing process. For PhD students, this communication is achieved by going through a ten-step method (“Ten reflective steps for rendering research socially relevant” (Pohl et al. 2017a, b) that helps them to bring to the fore their prior assumptions regarding the role of science, and the roles that their particular research projects play in society.

Competence field 2, “Reflecting about self and others” represents another core aspect of TD learning. In all courses students are asked not only to carry out activities, but also subsequently to reflect on why and how they have carried out those activities. This stands in contrast to other courses in our institution, where the activity itself is the end. In the bachelor’s course, the students reflect regularly by keeping an online learning journal where they document the progress of group work, and what they have learned from conducting interviews with experts and stakeholders. They also keep a record of how they have incorporated feedback from their lecturers. In regular meetings with each student group, lecturers ask students to reflect on what they are learning and their reactions to what they have learned. In the master’s course, the reflection is less explicit, but is an inherent part of the working process because the students have to organize their own goals. Through discussions, they have to come to a consensus about what they would like to prioritize in an open-ended problem setting. In the Winter School, specific exercises help participants to reflect on what they believe in, in relation to their research, and how these beliefs might affect the outcomes of their research. Offering time for this reflection is a key aspect of the Winter School. It enables participants to develop their own ideas about what role science plays and should play in society from their personal point of view.

Competence field 3, “Applying concepts to the real-world”, represents a third core aspect of TD learning. With this competence, we aim for students to be able to appropriately apply conceptual knowledge of environmental sciences to specific contexts, and simultaneously, to exercise practical skills to deliver the required end products. This competence field expects students to develop the ability for abstract thinking and the capacity for being able to accomplish practical tasks of “getting things done”. In the bachelor’s course, the abstract component is being able to qualitatively model a real-world system related to the problem statements they have framed, and to identify influencing factors in the system using computer software. The practical component is the ability to organize meetings and develop a group work schedule such that they can coordinate and complete a complex task over a sustained period of time, using skills such as project organization and time management. We do not explicitly “teach” these skills. Instead, students learn from each other, learn by doing and learn by making mistakes along the way. In the master’s course, the conceptual component is learned through becoming acquainted with the scientific literature on the topic through deskwork. They identify relevant methods and tools for their research topic. They also have to decide how to delimit their research topic based on available resources and on what are relevant themes for stakeholders. The practical component is that they must work in groups to agree on a research direction and be able to organize themselves in order to complete the tasks they have set for themselves. In the Winter School, participants are expected to understand the conceptual framework for transdisciplinary research and stakeholder engagement. They are also expected to make conceptual leaps between their own research and transdisciplinary research. The practical component is that they have to organize an event with stakeholders in a Swiss village, such that everyone will benefit from the process in some way.

Competence field 4, “Framing complex problems with others” is a fourth core aspect of our courses. Given a real-world topic and its accompanying frustrations and uncertainties, students are able to identify and frame clear, relevant problems in collaboration with those who have a difference of perspective or opinion. This competence, perhaps more than all others, encompasses the transdisciplinary approach to learning. The fact that students, instead of lecturers, are expected to frame the problem means that the lecturers give up any claim over knowing the “right” solution. This changes the power dynamic so that students are also responsible for holding knowledge alongside the lecturers. An important aspect of this competence field is that students are able to reflect upon, trust, and test their own intuitions, rather than rely exclusively on an external resource to justify decisions that are made. This process of framing problems reflects what students may be expected to do in the real world after completing their studies. Problems do not arrive at their desks pre-defined, and much energy has to be devoted to clarifying exactly where tensions lie.

From these core competence fields, it might become apparent that the role of the "teacher" in our courses is much more that of a coach or facilitator rather than that of a professor lecturing at the front of the class (Stauffacher et al. 2006). PowerPoint slides are reduced to a minimum and much of the learning occurs as the students struggle to complete a complex task. Students are expected to lose their way at some point along the journey. Our job is to help them through these small, perceived failures so that they do not lose sight of the main goal and do not feel as if they are alone in this struggle. We advise them on how to manage group processes and relationships and cultivate trust between students and the communities in which we work. We also provide resources in terms of foundational readings, research skills, interviewing skills, and stakeholder contacts. We spend much time on giving feedback on the work they produce along the way. This is the main way in which we "teach". The students are expected to react to this feedback through improvements they make in their process or output. Table 12.4 gives details about which learning dimensions are embodied by each competence field.

Table 12.4 Summary of relationship between competence fields and learning domains

<table>
<tr><th rowspan="2">Learning Domains</th><th rowspan="2">Dimensions of Domain</th><th colspan="6">Competence fields of TdLab courses</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th></tr>
<tr><td rowspan="6">Cognitive[10] (Knowledge)</td><td>Remember</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Understand</td><td rowspan="3">B.Sc</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Apply</td><td></td><td>B.Sc; M.Sc; PhD</td><td></td><td rowspan="4">M.Sc</td><td rowspan="3">B.Sc; PhD</td></tr>
<tr><td>Analyze</td><td rowspan="2">B.Sc; M.Sc</td><td></td><td rowspan="2">B.Sc; M.Sc; PhD</td></tr>
<tr><td>Evaluate</td><td></td><td></td></tr>
<tr><td>Create</td><td></td><td></td><td></td><td></td><td>B.Sc</td></tr>
<tr><td rowspan="5">Affective[11] (Attitude)</td><td>Receive phenomenon</td><td></td><td></td><td rowspan="5">B.Sc; M.Sc</td><td rowspan="5">B.Sc; M.Sc; PhD</td><td rowspan="2">M.Sc; PhD</td><td rowspan="2">B.Sc; PhD</td></tr>
<tr><td>Respond to phenomenon</td><td></td><td></td></tr>
<tr><td>Value</td><td>B.Sc; PhD</td><td rowspan="3">B.Sc; M.Sc; PhD</td><td></td><td></td></tr>
<tr><td>Prioritize</td><td></td><td></td><td rowspan="2">B.Sc</td></tr>
<tr><td>Internalize values</td><td></td><td></td></tr>
<tr><td rowspan="5">Psychomotor[12] (Skills)</td><td>Imitate</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Manipulate</td><td rowspan="2">B.Sc</td><td></td><td></td><td></td><td></td><td rowspan="3">BSc</td></tr>
<tr><td>Refine</td><td></td><td rowspan="2">B.Sc; M.Sc</td><td></td><td></td></tr>
<tr><td>Articulate</td><td>B.Sc</td><td></td><td></td><td></td></tr>
<tr><td>Naturalize</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

[a]Cognitive dimensions are defined following the revised Bloom Taxonomy by Anderson and Bloom (1913–2001)
[b]Affective dimensions follow Krathwohl et al. (1964)
[c]Psychomotor dimensions follow Dave (1975)

From Table 12.4 we see that the number of dimensions addressed by each competence field ranges from 4 to 11. This indicates that the breadth of the competence fields varies, so that some target a specific set of skills, while others employ a broader skill set.

In addition, the “Analyze” dimension within the cognitive domain is present in all but one of the competence fields, making it our most frequently addressed dimension across all domains. The ubiquitous presence of this cognitive dimension demonstrates our attempt to balance the needs of fostering cognitive and affective dimensions simultaneously.

Certain learning dimensions are not included in our learning objectives. These include the “Remember” dimension in the cognitive domain, and the “Imitate” and “Naturalize” dimensions in the psychomotor domain. The “Remember” and “Imitate” dimensions are associated with rote learning abilities. The “Remember” dimension represents students’ ability to recall or retrieve learned information. The “Imitate” dimension represents the ability to observe and pattern behaviour after someone else. The “Naturalize” dimension represents the mastery of a performance until it becomes second nature or natural, without a need to think much about it. This dimension represents a level of expertise that we do not expect our students to achieve during the course of study and it is therefore not a target. These skills get built up over time through repetition—time that we do not have during the course of one class. However, it is our hope that students will build up enough interest in the transdisciplinary approach for them to become experts by seeking out future experiences for themselves.

12.5 Discussion: Linking Design Principles for Transdisciplinary Research in Sustainability Science to Learning Domains

In the previous sections, we have looked in detail at the types of competencies TdLab courses are concerned with, and what this reveals about the nature of our teaching. How do we know whether this teaching serves the actual future needs of students, should they choose to practice transdisciplinary research in the future? In the absence of any longitudinal studies that reveal the impact of these courses on students (although we could claim leading scholars in TD have been former students, e.g. Daniel Lang, Arnim Wiek, amongst others), we will have to be satisfied with a conceptual assessment of the possible connections between what we teach and what students’ future needs are. As the basis for this assessment, we use Lang et al.’s design principles for transdisciplinary research in sustainability science, which provides an outline of the activities that need to be successfully carried out in order to ensure a productive outcome from a transdisciplinary project.

The transdisciplinary research process has three phases (Lang et al. 2012; Jahn et al. 2012). Phase A is collaborative problem framing and building a collaborative research team. Phase B is the co-creation of solution-oriented and transferable

Table 12.5 Linkage between TdLab competence fields and transdisciplinary design principles

<table>
<tr><th colspan="2" rowspan="2">Design Principles for transdisciplinary research in sustainability science (Lang et al. 2012)</th><th colspan="6">Competence fields of TdLab courses</th><th rowspan="2">Corresponding Learning Domain(s)</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th></tr>
<tr><td rowspan="4">Phase A</td><td>Build a collaborative team</td><td></td><td colspan="2">BSc; MSc; PhD</td><td></td><td></td><td></td><td rowspan="4">Cognitive; Affective</td></tr>
<tr><td>Create joint understanding of problem</td><td></td><td></td><td></td><td rowspan="2">BSc; MSc; PhD</td><td></td><td></td></tr>
<tr><td>Define boundary/ research object</td><td rowspan="2">BSc</td><td></td><td></td><td rowspan="2">MSc; PhD</td><td></td></tr>
<tr><td>Design methodological framework</td><td></td><td>BSc; MSc</td><td></td><td></td></tr>
<tr><td rowspan="2">Phase B</td><td>Assign and support roles</td><td></td><td></td><td rowspan="2">BSc; MSc; PhD</td><td></td><td></td><td></td><td>Cognitive; Affective</td></tr>
<tr><td>Adjust methods</td><td></td><td></td><td></td><td>MSc</td><td></td><td>Cognitive; Affective; Psychomotor</td></tr>
<tr><td rowspan="3">Phase C</td><td>Integrate results in science and practice</td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="3">Cognitive; Affective</td></tr>
<tr><td>Generate products</td><td></td><td></td><td>B.Sc; M.Sc</td><td></td><td></td><td rowspan="4">BSc</td></tr>
<tr><td>Evaluate impact</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Across all phases</td><td>Evaluate process</td><td></td><td></td><td></td><td></td><td></td><td rowspan="3">Cognitive; Affective; Psychomotor</td></tr>
<tr><td>Mitigate conflict</td><td></td><td colspan="3">BSc; MSc; PhD</td><td></td></tr>
<tr><td>Ensure stakeholder participation</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

knowledge through collaborative research. Phase C is (re-)integrating and applying the co-created knowledge. Within each of these phases, design principles are proposed which serve as a heuristic for guiding researchers on building a successful process. We believe it is pertinent to compare the skills that are required by a real transdisciplinary project with our teaching objectives. Like the competence fields, each design principle can be divided into multiple components that can be categorized into the various learning domains. One way of assessing the aim of transdisciplinary learning, then, is by comparing its goals with these design principles.

Table 12.5 makes the link between each design principle of transdisciplinary research in sustainability science and its projected corresponding learning dimensions. We make a comparison between the skills needed to fulfill these design principles and our teaching goals.

First, it seems that the affective domain competencies, like in transdisciplinary learning, are key to transdisciplinary research projects. Across all phases of transdisciplinary research, there are design principles which require researchers to perform tasks that involve them receiving and responding to phenomena (especially in the context of collaboration). The researchers need to identify and prioritize their own values in order to formulate a plan of action, and to adjust and apply the methods repeatedly. The ability to adapt to circumstances, which is central to the process of transdisciplinary collaboration, is dependent in large part on an individual's ability to listen to and understand others' points of view, and to incorporate this understanding into future action. A degree of sensitivity is required in order to perceive individual needs adequately and to react to these needs.

Second, each phase of transdisciplinary research and even each design principle that make up the phases, crosses into more than one learning domain and requires mastery of a combination of diverse skills. For example, in Phase A, the design principle "Create a joint definition of understanding of the problem" requires one to find research questions (cognitive domain) and to "integrate and balance contradictory normative claims" (affective domain). Only when both types of tasks are addressed is this stage successfully completed. The combinations of competencies come mostly from the cognitive and affective domains. We argue that this cognitive-affective domain crossover is a defining feature of both transdisciplinary learning and research. When diverse worldviews are included in a single collaboration, which is always the case with transdisciplinary research, it is not sufficient for scientists to simply provide facts and figures; it is also necessary for them to be aware of differences in values, validation processes, and ways of working and thinking between the collaborators, in order to be able to identify their own perspectives in this process.

We overlay the TdLab competence fields with the design principles of transdisciplinary research to compare the coverage of these skills by our courses (See Table 12.5). Phase A design principles are addressed most frequently by the TdLab competence fields, indicating that we focus on the student's ability to orient, frame, and enable the research process. Phase B and Phase C design principles are also addressed, but to a lesser degree than Phase A principles. This indicates that doing the research and using, applying, and implementing research results is not given as much focus as the Phase A skills. Of the Phase A design principles, the "Define boundary/research object" and "Design methodological framework" principles are addressed across the greatest number of competence fields.

Competence field 3 captures the most design principles, as it covers half of the principles, while competence field 1 is the most focused, as it includes only two principles in its learning objective. This indicates that competence field 3, the ability to apply concepts effectively within group settings, may be the competence field that is most frequently needed across all phases of transdisciplinary research.

12.6 Conclusion

The contribution of this chapter is twofold. First, we have provided a model of transdisciplinary learning that is linked to the practice of TD research. It would be possible for other TD courses to build upon this pedagogical framework so that their facilitators or lecturers would have more confidence regarding whether key TD learning objectives are met, and so that they could ensure that key abilities are transmitted to future "transdisciplinarians". Like any framework that is created heuristically bottom-up, it is subject to further changes and improvements through iterative testing and validating in the future. Second, by articulating TD-specific competence fields we make it possible to link TD skills to the broader field of education by overlaying them with the cognitive, affective, and psychomotor learning domains. Therefore, TD learning can be utilized in higher education to bridge diverse learning domains, making it a valuable approach to facilitating learning in general, separate from its focus on developing TD-specific skills.

By delineating the attributes of TD learning, we are able to confront different conceptions of transdisciplinarity itself. Though the concept is difficult to define in the abstract, there are certain actions which embody TD research: communicating assumptions and normative values, reflecting on one's own perceptions and biases, appropriately applying conceptual knowledge to specific contexts to deliver useful products, identifying and framing clear, relevant problems in collaboration with those who have contrasting perspectives or opinions, translating real-world problems into viable research questions, and exploring and develop solutions for real-world problems—these are things which transdisciplinarians should *do*. The reflexivity needed to develop these core abilities is at the heart of what we try to foster in our students. Rather than relying only on their intellectual capacities to solve problems, we encourage students to understand with their whole being.

References

Anderson, L. W., & Bloom, B. S. (1913–2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (Abridged, Ed.). New York: Longman.

Anderson, L.W., Krathwohl, D.R., Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., Wittrock, M.C. (2001). A Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of Educational Objectives.New York: Pearson, Allyn & Bacon.

Bloom, B. (1956). *Taxonomy of educational objectives* (2nd ed.). New York: Longman.

Dave, R. H. (1975). *Developing and writing behavioral objectives* (R. J. Armstrong, Ed.). Tucson:Educational Innovators Press.

Gibbons, M., Limoges, C., Helga, N., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge*. London: Sage.

Hirsch Hadorn, G., Bradley, D., Pohl, C., Rist, S., Wiesmann, U. (2006). Implications of transdisciplinarity for sustainability research. Ecological Economics 60:119-128.

Jahn, T., Bergmann, J., & Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics, 79*, 1–10.

Klein, J. (2017). A taxonomy of interdisciplinarity. In R. Frodeman, J. T. Klein, & R. Pacheco (Eds.), *The Oxford handbook of interdisciplinarity: The boundary work of definition* (pp. 21–34). Oxford: Oxford University Press.

Krathwohl, D., Bloom, B., & Masia, B. (1964). *Taxonomy of educational objectives the classification of educational goals*. New York/London: Longman.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., et al. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science, 7*(S1), 25–43.

Meeth, L. R. (1978). Interdisciplinary studies: A matter of definition. *Change: The Magazine of Higher Learning, 10*, 10.

Nicolescu, B. (2010). Methodology of transdisciplinarity – Levels of reality, logic of the included middle and complexity. *Transdisciplinary Journal of Engineering and Science, 1*(1), 19–38.

Pohl, C., Hadorn, G., & der Wissenschaften Schweiz, A. (2007). Transdisciplinary research. In *Principles for designing transdisciplinary research*. Munich: Oekom Verlag.

Pohl, C., Truffer, B., & Hadorn, G. (2017a). Addressing wicked problems through transdisciplinary research. In R. Frodeman, J. Klein, & R. Pacheco (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 319–331). Oxford: Oxford University Press.

Pohl, C., Krütli, P., & Stauffacher, M. (2017b). Ten reflective steps for rendering research societally relevant. *GAIA – Ecological Perspectives for Science and Society, 26*(1), 43–51.

ProClim. (1997). *Research on sustainability and global change – Visions in science policy by Swiss researchers*. Bern: Swiss Academy of Sciences (SAS).

Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*, 155–169.

Stauffacher, M., Walter, A., Lang, D., Wiek, A., & Scholz, R. (2006). Learning to research environmental problems from a functional socio-cultural constructivism perspective. *International Journal of Sustainability in Higher Education, 7*(3), 252–275.

Stokols, D. (2014). Training the next generation of transdisciplinarians. In M. O'Rourke, S. Crowley, S. D. Eigenbrode, & J. D. Wulfhorst (Eds.), *Enhancing communication and collaboration in interdisciplinary research* (pp. 56–81). Los Angeles: Sage.

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic programme development. *Sustainability Science, 6*(2), 203–218.

Chapter 13
Collective Learning in an Industry-Education-Research Test Bed

Tanja Golja, Shilo McClean, and Krista Jordan

13.1 Introduction

> If you do a paternity test on many of the modern world's most important ideas or institutions, you will find, invariably, that leisure and play were involved in the conception as well. (Johnson 2016, p. 10)

Innovation and creativity are commonly viewed as key drivers in the modern world. In order to harness them, great minds have tried to fasten these two driving forces into a process akin to the scientific method or formalized step-by-step guides to creative work and innovation. However, Johnson's historical study of innovation (2016) tells a different story: one that foregrounds how play can be a space where valued innovations emerge, often through collaborative "playing together". How then do we create the conditions for such emergence and innovation? This question is integral to understanding why one of the world's leading animation studios teamed up with a university, and why the university was eager to step off the firm foundation of well-established traditions to partner in a bold innovation.

A driving ambition for both parties was to effect creative collaboration between the academy and industry by making something tangible that neither of them could create independently of the other. To realize those aspirations, they came together and put into practice a designing-by-doing approach to exploring possibilities. In so doing, their co-created initiative would tackle fundamental and contemporary shifts in business and society by test bedding a model that could enable a matching

T. Golja (✉)
Faculty of Transdisciplinary Innovation, University of Technology Sydney, Sydney, NSW, Australia
e-mail: Tanja.Golja@uts.edu.au

S. McClean
UTS Animal Logic Academy, University of Technology Sydney, Sydney, NSW, Australia

K. Jordan
Animal Logic, Sydney, NSW, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_13

paradigm shift in education. Fundamentally, that collaboration generated an opportunity for collective learning.

In this chapter, we begin to describe and analyze this collaboration and its creative practices. As a result, we confront the basic principle of transdisciplinarity, that is, mutual learning (often described in terms of collaboration, collective learning, transformation, co-production, amongst others), where learning is conceived broadly as "the adaptation process inherent in interaction and joint problem solving between science [or the academy] and society" (Scholz 2000).

Yet, recognizing and "measuring learning outcomes [in these transdisciplinary environments] … is a theoretical and methodological challenge" (Vilsmaier et al. 2015, p. 589). The depth of this challenge is clear in Westberg and Polk's (2016, p. 385) words:

> While there is much emphasis on dialogue and participation in the TD discourse, as well as on frameworks and methods for promoting them (Bergmann et al. 2012; Pohl and Hirsch Hadorn 2007; Scholz and Steiner 2015), there is little theoretical attention directed at what happens within such activities, at the mechanisms underlying how knowledge exchange [namely learning] occurs in practice.

In these circumstances, researchers often deal with limitations by taking a coarse-grained view of learning, as Pohl et al. (2010, p. 278) also identified in their study: "[The researchers] relied on learning by doing rather than on a systematic analysis, choice of role and use of method, and on a rather intuitive orientation based on an equally rather implicit understanding of a collective learning process". Educational researchers, too, have identified the need for empirical investigations into how learning actually occurs in such social contexts (Forsyth 2008, 2010; Forsyth and Schaverien 2004, 2005), arguing that "obviously, the task of developing strong explanatory frameworks that take us well past simple descriptions is urgent" (Forsyth and Schaverien 2004, p. 24).

UTS is increasing its offerings of transdisciplinary degree programmes, and the following acts are therefore becoming crucial: detecting how collective learning occurs in complex transdisciplinary learning environments; gaining an understanding of collectivity; and learning how to design principled educational opportunities that enable collective transdisciplinary developments to thrive and realize significant worth. To understand the nature of the more fine-grained investigations needed to yield such insights into collective learning, we set out to trace the processes and the narrative of this industry–university collaboration, with due consideration of how the insights gained might also have relevance for other transdisciplinary initiatives and communities.

13.2 An Industry–University Collaboration: Establishing the UTS Animal Logic Academy

In early 2015, UTS and Animal Logic (an award-winning animation and visual effects (VFX) studio) joined forces to explore opportunities for co-developing an industry-led education programme which would respond to an increasing need for graduates to work in the digital animation, VFX and related CGI fields of visualization (including virtual reality, augmented reality, mixed reality and other immersive visual experiences). This partnership grew out of an acute understanding that to be future-careers focused requires a symbiotic relationship between education providers and industry that is cognizant of technological innovation and emerging professional practices.

As a world leader in CGI for feature films, Animal Logic is renowned for its innovative creative work in *The LEGO Movie*, *Happy Feet, The LEGO Batman Movie*, *The Great Gatsby* and many more (see Animal Logic 2012, 2014; Miller-Zarneke 2017). As an education provider, UTS has long been an innovator in practice-oriented education that is research-inspired and integrated, and which supports academic rigour with cutting edge technology to equip graduates for lifelong learning. Their year-long joint exploration of industry-led education became the genesis for the UTS ALA (UTS Animal Logic Academy), a first-of-its-kind practice-based university–industry initiative offering postgraduate qualifications through coursework and research opportunities. The creative practices and embodied principles of the CGI industry formed the foundation of the UTS ALA's core values, as enacted in its practices. To that end, a Master of Animation and Visualisation (MAV) was designed to support CGI artists in building impactful future-facing careers, with the intention of ensuring that the relevance of studio practice would be foregrounded.

The professional practice of CGI artists encompasses an extremely broad range of creative specializations (including software engineering, for example). CGI artists frequently move across specializations within the industry, and also move from studio to studio (for a considerable part of their careers), as part of a global workforce that gathers in centres of CGI excellence. Spread across the globe, this extensively dynamic community is highly connected and truly collaborative, and it is an exemplary partner for an educational institution seeking to learn how digital industries are shaping the future.

13.3 Industry-Led Postgraduate Education: Designing the MAV

Over the course of a year beginning in mid 2015, through an initial series of sustained workshops with key creatives at Animal Logic and the Head of Transdisciplinary Education Innovation at UTS, the production company's creative culture, knowledge specializations, workflow dynamics and entry level requirements into this industry were elicited and mapped extensively. For example, industry-derived desirable graduate capabilities were categorized under three key sets of practices:

1. highly proficient, imaginative and rigorous craft practice
2. adaptable and resilient practices, critical analysis and research skills
3. dynamic system practice, communication and collaboration.

This knowledge sharing formed a framework for discussions about the structure of the proposed MAV in subsequent workshops with representatives from academia, film and digital industry partners, and CGI industry experts. These discussions led to the MAV being sketched out as an intensive, one-year master's degree programme, undertaken as three studios: The Connected Studio (Studio 1), The Collaborative Studio (Studio 2), and The Challenge Studio (Studio 3). While Course Intended Learning Outcomes were defined through the collaborative sessions, detailed curriculum planning and realization became the responsibility of the UTS ALA leadership in partnership with Animal Logic. Put simply, the three Studios set out to test, in order: What can you do? How fast can you learn and respond? How fast and well can you do what you've learned?

Studio 1 tested creative practice that would be held to industry standards for efficiency, visual power, technical and creative quality. Creative practice was informed by creative and technical problem solving and the experience of hub test generation and iteration.

Studio 2 was a test bed for innovative creative and technical practice at the nexus of emerging technologies. Taking the results and practice from Studio 1, which worked to well-established industry standards, Studio 2 required extending that initial approach into the area of industry-quality innovation that could be delivered for emerging platforms (e.g. virtual reality, augmented and mixed reality).

Studio 3 would realize the work started in Studios 1 and 2 and deliver highly innovative production outcomes that could only be achieved through the exploration of advanced problem solving and engagement with industry-defined creative challenges. The Studio 3 output had to be innovative, persuasive and compelling in its technical and creative expression, and it had to be recognized as such by industry.

Most new professional studios come together through connections that already exist within industry. The crew members have some professional experience from other studio environments and are already familiar with the industry's dynamic workflows, cultural nuances and professional standards. The challenge for the MAV would be to form its crew with relatively junior members, many entering directly from undergraduate programmes without professional experience. To lead this relatively inexperienced team of artists in achieving innovative work, seasoned professionals from industry were needed as leadership of the UTS ALA.

To operate in every respect as a professional studio, the artists were recruited as they would be for professional engagement in an animation studio and when enrolled in the MAV they would be required to be in the UTS ALA studio from 9:00 am until 5:00 pm, Monday to Friday, from mid-January until the end of November. With only two scheduled 1-week breaks, they would have to work together in a cohort model using industry work practices and at industry speed. The leadership would need to be adept at creating a culture and collaborative connections between the artists so that the cohort could engage in professional practice quickly in order to meet the demands posed in Studio 1.

As they progressed through the three Studios, each of the participants would be challenged to expand their craft and technical practices. Structured in crew roles, they would work across the disciplines of:

- story (storyboards, editing, pre-visualization)
- art (concept art, graphic design, character design, environment design, prop design)
- assets (modelling, surfacing, digital matte painting)
- performance (rigging, animation, camera, layout, effects (FX), crowd systems)
- visual (lighting, compositing)
- technical management
- project management
- creative management
- software engineering.

From the first days of their MAV practice, the artists would engage in collaborative problem solving and actively share knowledge. The artists' and the Studio's success would depend on the ability to recognize, understand and respond to the necessarily iterative, co-dependent and evolving nature of techniques and creative processes within a professional CGI workflow. Fundamental to the whole process was the need to ensure that the participants would be able to analyze critically how collaboration operated responsively across disciplines in an evolving workflow, resulting in graduates adept and ready to apply this throughout their careers. The UTS ALA would have to impart these practices to its crew, very swiftly, starting in The Connected Studio.

13.4 The Connected Studio: Initiating a Hub Test

In a hub test, production studios confront the very real problem-solving demands that a creative project will pose. It is an opportunity to prototype and work through anticipated project challenges. The work resulting from a hub test does not need to be part of the final product, creation or visualization; rather, it assists in resolving (or working towards resolving) various challenges in the final process. The collective experience and collaborative dynamic of the team comes to the fore during this high-level problem-defining and solving phase. It entails future thinking, grounded in what needs to be solved, communicated, expressed, encapsulated, emoted, budgeted, scheduled and so on, in the full-scale, final work. A key value of a hub test is in forecasting the potential successes or failures in the major project or process. Indeed, the principles that guide innovative development find their origins in hub tests.

In essence, a hub test provides a studio with the means by which to exercise its creative acumen while also measuring the technical innovation and resources needed to deliver a fresh creative response to the brief set for them by a film studio seeking their participation as a production partner. For example, in the case of *The LEGO Movie*, the Animal Logic hub test brief seemed to have simple requirements: the representation of the LEGO characters and sets had to look like they were made from LEGO and appear to function like real-world LEGO. Implicit challenges were defined:

- How do you connect as an audience to LEGO characters that appear virtually identical bar relatively minor variations in props, accessories, colour, hair type?
- How do LEGO characters express emotion?
- How do you visualize organic natural elements in LEGO?
- How does LEGO in organic forms, like fire and water, move?
- How do we execute this creative vision with, yet to be fully realized, technical challenges at SCALE, on budget and within a restricted time frame?
- How do we convince our clients that all of this is possible and that we can do it?

As is so often the case, the more straightforward the challenges sound, the more complex the solution will prove to be. In the case of the hugely successful *The LEGO Movie*, Animal Logic drew on months of R&D by its in-house team of software engineers and over 2 years of groundbreaking design, animation, and production by a crew of nearly 500 artists contributing a multitude of specialist skills.

By comparison, however, defining a hub test for the MAV's Studio 1 would not have the same real-world pressures, or resources, but would provide the participants in the programme the same kind of challenge that CGI studios all face when they are asked for their creative response to client proposals. As an entirely new initiative, UTS ALA would be working under conditions comparable to those of a start-up studio. Participants would have at their disposal university-funded premises designed, outfitted and equipped with industry-standard hardware and software, and they would be supported by production-experienced leadership to ensure that the day-to-day delivery of the programme would reflect the physical environment, the structure, and work practices of industry.

Very early, the UTS ALA leadership recognized that the development of the MAV was in itself a hub test for the newly established Academy. At every opportunity, they sought to push the educational boundaries by establishing typical real-world challenges but without resorting to standard hypothetical case study parameter setting. Thus, while it would have been quite easy to have designed creative briefs that were similar to the kinds that are brought to commercial studios—for example, by describing a specific scenario or by offering artists a range of sample briefs and letting them choose one to work on collectively—the leadership opted to "stay real" and operate as a start-up. Even though the UTS ALA would not compete with commercial studios and bid for projects, like any new studio, it needed to establish its collective voice—an expression of the artists who belong to the studio. With that in mind, the UTS ALA leadership chose the harder path of taking a completely generative, open brief to give cohorts the greatest freedom for a collective creative response, as ultimately, the MAV's goal was to lead the development of creative practice both for individual artists and for the UTS ALA as a studio.

That decision would prove to be crucial for Studio 2 where the collaborative bonds would be tested and the challenge lay in maintaining cohesion across the cohort as they took responsibility for building a collective vision. In that studio, they would need to develop a range of hub test scenarios and research challenges for studio-generated ideas in agile teams.

13.5 Studio 1 2017 Cohort: Shaping Practice Through Collective Learning

The first 2 weeks of Studio 1 were shaped as a boot camp focusing on trust building and identifying what each member of the cohort brought to the studio, technically and creatively. Participants worked together on a level playing field, making LEGO creations and colouring an original artwork. In this way, the leadership established from the very beginning that the goal was to build and play well together. The next challenge lay in drawing out of the cohort as a whole, a creative brief that would speak to their ambitions and inspirations, individually and collectively.

Like most creative work, the process experienced the ebb and flow of excited discovery and the dread feeling that good ideas had just slipped away and turned into a handful of dirt. The process of working up the hub test for Studio 1 involved extensive research and sifting through reference materials. The starting point lay in examining cherished favourites: the films and shots that inspired the artists to pursue careers in the CGI industry. However, as much as this was greatly enjoyed, the Academy leadership did not permit the crew to rest in this comfortable creative space. The cohort was repeatedly asked to dig deeper, to look wider and to analyze their research to find something that surprised them. Only then could they begin to sketch the shots that Studio 1 would produce.

During the design stage for the MAV, the Learning and Development Manager at Animal Logic and the Head of the UTS Animal Logic Academy had set the hub test parameters for the cohort: to design and deliver feature film quality shots with no more than two or three locations, one or two characters and shots of five to fifteen seconds' duration. However, when it came to sketching the ideas for the hub test, the cohort immediately fell into the trap of pitching short film ideas, setting up competing ideas, or trying to combine a mish-mash of all their ideas into one to somehow come up with the best idea for a complete short film—the traditional output of an undergraduate programme. The leadership's goal was not to reject those pitches outright, but to bring the cohort to the realization that by taking that direction, they were not pulling together to sketch out something that reflected their shared vision and would deliver a collective work that emerged from breaking new creative ground.

Thus, it was only when the cohort worked together to establish a premise that had the depth needed to explore new territory technically and creatively, a premise that took their ideas into more innovative realms, that the leadership stepped in to progress this work into shots. The cohort could then pool their collective and individual skillsets to meet the Studio's first production goals. This boundary setting was undertaken at the leadership level to ensure that the creative and technical brief would be of an achievable size, as per an industry hub test, which ultimately aimed at realizing the collaboratively-established premise.

13.5.1 Industry Response to Studio 1

The cohort presented the hub test from Studio 1 to an Animal Logic audience. As an initial response, Guy Griffiths (Director of R&D, Animal Logic) recognized the level of team and community building that had been achieved by the group. He understood that Studio 1's focus on building a collaborative culture was key to the professional quality of the work, especially when he took into account the timeframes, processes and challenges inherent in producing a tight "hub test" in a short period, and he was impressed with how that had been achieved by people who had never met before. Zareh Nalbandian (CEO, Animal Logic) also congratulated the cohort on their achievement in working collaboratively to meet industry expectations. Animal Logic then challenged the MAV artists to keep going, and reach for something entirely new, something surprising—the underlying goal of Studio 2. In effect, the cohort had proven they could deliver professional work that would be recognized by industry professionals, and they were invited to do more—the industry's own way of acknowledging professionalism in creative works.

In summary, the first studio adhered to the industry's expectations for successful collaborative work. It was playful and authentic; the participants both within the course and at the institutional level were fully engaged in the realization of the outcomes. It drew upon and reflected the whole, and in doing so created a truly synergistic outcome. The process enriched the participants by building skills, insights, strengths and new ways of seeing (critical for artists) and being. MAV's Studio 1 creative outputs produced something of substance that could be valued independently of the creators, including images, and VR and AR experiences. For the industry partners, Studio 1 was a place to collaborate and create new ways of growing their respective bases.

13.6 Making Sense of Collective Learning: Towards Addressing Three Challenges

In his investigation into collectivity, Forsyth (2008) argued that collaborative learning communities that engage in both local and global systemic transformation confront three types of challenges: ethical, theoretical and pragmatic. He sought to address the urgent need to describe, analyze and theorize teachers' collective learning. An Australian Research Council Linkage Project, DESCANT-SciTech (Designing e-learning systems to celebrate and nurture teaching in Science and Technology) involving collaboration between UTS and the New South Wales Department of Education (DET), provided Forsyth with a context for confronting those three challenges that had to be met to make collective learning both possible and likely.

We use those three identified challenges—the pillars of the learning ecology framework developed and tested in Forsyth's (2008) study—to begin examining the nature of collective learning in the early UTS ALA and MAV developments, and in the process, we distil and make explicit the principles that were being enacted in that collaborative industry-led initiative.

13.6.1 Responding to an Ethical Challenge: Democratic Professional Learning

A starting point for examining collective learning in the UTS ALA context is the extent to which the initiative afforded appropriate levels of autonomy to participants in their learning. This may be conceived of as a democratically-principled *ethical challenge* (after Forsyth 2008): in the case of the individual artists, the challenge is to ensure their voices were expressed in the collective work.

Multiple stakeholders—various industry partners, the university leadership, practitioners, academics, researchers—came together at different times to focus on educational development and professional learning, and transformation in the CGI industry. Additionally, while Animal Logic was the key industry collaborator in establishing the UTS ALA, early in the conversations they encouraged the active involvement of other industry partners who had adjacent areas of expertise to Animal Logic's.

By utilizing the hub test as a device for creative practice, Studio 1 enabled strengths and aspirations to be elicited from the cohort's individual and collective voices. That collective practice supported ongoing opportunities for open conversation and dialogue within the cohort, with the leadership team and with industry partners. As a team, they explored ways of capturing, distilling and representing their ideas and values, and ways of sharing them with others wherever appropriate to support the hub test work. Sustained open and frank conversation within the UTS ALA enabled participants to work through the challenges faced together, and to achieve a quality team outcome.

Furthermore, in this start-up environment, the cohort was provoked to push the boundaries of what they individually knew or thought they knew, as exemplified by practices enacted by the leadership and industry partners at the cutting edge of the CGI field. In that forge of experimentation, there was a recognition of the need to embrace uncertainty, and for the collaborative community (i.e. the cohort, the UTS

ALA leadership, and industry partners) to step beyond the boundaries of the known and into new domains, and in the process, to create innovative and successful outcomes. This community proactively stayed open to defining, addressing, researching and exploring creative solutions to complex problems collectively, and to seeing the value that would emerge.

To build a unified Academy and MAV required shaping a new collaborative landscape that drew upon the educational experience of the University and the industry experience of Animal Logic. Effectively, this was a test bed for both the university and the industry partner: a "make or break" situation in which the Academy itself would need to meet creative and technical standards for both industry and future-oriented education.

Invariably, staffing questions arose in offering an industry-led degree programme: Who was to be in the "teaching team" and what would be its role? What might be required of a leadership team? Rethinking the roles of this new collaborative landscape resulted in bespoke UTS ALA positions with a Head of Academy who could bridge academic and professional practice, and Creative and Technical Leads who were engaged directly from industry.

In essence, the industry–university partnership required that the MAV achieve genuine collaboration and establish "a common world" in the form of hub tests. By creating a culture of experimentation, the leadership team and industry partners encouraged all participants to stay open to new possibilities and venture into unknown territory, and to be candid about any issues that arose. That approach enabled participants to work through any challenges faced together in order to achieve a quality outcome.

Forsyth (2008) confirmed the value of adopting a political ecology perspective (Latour 2004) based upon three methodological principles, each underpinned by a set of ethical requirements. We now appreciate how these principles are also inherent to collective learning in the UTS ALA and MAV. These methodological principles are (after Forsyth 2008, p. 67):

1. Democratic knowledge building: ensuring all parties' rights (including cohort, leadership team, industry partners, researchers) to engage in a genuine negotiation of knowledge, including with the wider CGI community.
2. Maintenance of sustained perplexity (however uncomfortable): in preparation for the emergence of unforeseeable knowledge in the collective through a process that is truly experimental.
3. Diplomatic intervention: re-conceiving the role of teacher or researcher as a practitioner (and educational and academic) diplomat who is striving to establish an industry-led education-research initiative within an authentic knowledge-building context.

Once this first pillar was in place, the theoretical challenges became evident.

13.6.2 Responding to a Theoretical Challenge: Re-conceiving Collectivity

In exploring the phenomenon of collective learning, we are seemingly faced with having to explain and understand its occurrence within complex nested and coupled systems. Forsyth (2008) saw that necessity as a *theoretical challenge.* As in the case of his investigation, a generative learning theory (Schaverien and Cosgrove 1999, 2000) provides a starting point for also identifying and studying collective learning in the UTS ALA.

In a case study analysis of complex collaborative networks, Forsyth (2008, p. 69) distilled three theoretical stances, which seem to be represented in the UTS ALA case as well:

- A conceptual shift in which professional learners are conceived as collective entities, rather than only individuals: for example, establishing a startup studio with a cohort model, where successful outcomes required expertise from various disciplines utilized by the CGI and associated industries.
- A view of learning as an adaptive change within these collective entities, whether they are groups, networks or systems: for example, close connections with industry developments and an educational responsiveness to change in contemporary society; a MAV experience that is focused on individual and team capability development for connecting, resilient and adaptive practices.
- A similarity between the characteristics of networked/collaborative learning contexts and the characteristics of complex adaptive systems: in particular, their self-organizing dynamics and nested structure: for example, the MAV cohort's collaborative learning as emulating the complex dynamic system practices of an innovating startup studio, and in interaction with a cutting-edge industry partner (Animal Logic).

The MAV could conceivably be another case of re-presenting collective learning, a generative way forward (after Forsyth and Schaverien 2004). On that generative learning view (Schaverien and Cosgrove 1999, 2000), we can now recognize that the hub test, for example, provides a powerful means by which the Academy could generate and test on value any creative idea or proposal during Studio 1, and keep those that survive the tests for the next regenerative round. This theoretical view enables us to recognize and detect when learning occurs, in generative learning terms, and to consider how best to support innovative development over time, for both individuals and the collective. Furthermore, we recognize a generate-test-regenerate (or selectionist) mechanism (Plotkin 1994) could account for creativity and novel outcomes in the UTS ALA: a cycle that was at once creative in its generative and regenerative phases and rigorous in its testing phase.

The interdependencies, the adaptable and resilient practices, the dynamic systems and collective complexity apparent in the MAV learning environment, and supported as desirable graduate capabilities, suggest evidence of the three theoretical principles that Forsyth (2008, pp. 77–8) distilled in his investigation for studying collective learning. These shared principles are:

1. Recognizing complexity: suggesting that "gaining insight into learning within a complex system may require the study of multiple, and often non-linear, interactions within and across parts of that system (Thelen 2005)".
2. Recognizing continuity in time: which "serves as a reminder of the temporal nature of learning and the importance of experiential history to adaptive self-organization".
3. Recognizing dynamic stability: which represents "a challenge to conceptions of development and learning that focus on stability and end-points … [In contrast,] *mapping* the "collective variable behaviour" over time (Thelen and Smith 1994, p. 58) … allows research to characterize the stability of dynamic patterns within and across various levels of an adaptive complex system or network".

Preliminary findings in our collaborative research suggest the value of Forsyth's learning ecology framework for it offers a "conception of collective learning that incorporates the *ethical pragmatics* of political ecology (Latour 2004) with the *theoretical pragmatics* of a generative learning theory and complexity sensibilities (for example, Davis and Sumara 2006; Axelrod and Cohen 2000)" (Forsyth 2008, pp. 377–8). So, while collective learning in the UTS ALA and MAV could be described and explained by considering how ethical and theoretical challenges were addressed, we turn now to how the pragmatic challenge—the third pillar of Forsyth's learning ecology—is being met.

13.6.3 Responding to a Pragmatic Challenge: Designing Collective Development and Research

Being highly attuned to collectivity as fundamental to its success, the CGI industry has developed its own practices to support mutual learning. Collaborative knowledge emerges from diverse practices across a range of industries and disciplines, and the importance of collaborative knowledge discovery and sharing is understood at every level. Reflecting on that dynamic, in his book *Creativity, Inc.* the President of Pixar Animation, Ed Catmull, discussed "several of the mechanisms we use to put our collective heads into a different frame of mind" (Catmull 2014, p. 192). Catmull went on to describe in detail how and why a particular set of mechanisms is used to support their collaborative creative practice (Catmull 2014, pp. 192–222). While those mechanisms, techniques and creative practices were designed into the industry-led MAV to support collective learning, the UTS ALA leadership team also developed other mechanisms supporting collective emergent practices in the Studio 1 context.

In the plainest possible terms, the MAV is a test bed for practice-based research. In her chapter entitled *Research and creative practice*, Linda Candy made this observation: "Practice that is creative is not only characterized by a focus on creating something new, but also by the way that the making process itself leads to a transformation in the ideas, which in turn leads to new works" (2011, p. 33). This applies strongly to the work of CGI studios that are groundbreakingly innovative in their aesthetic and technical achievements: a hallmark of Animal Logic's body of work. The centrality of that embodied creative practice in the industry-led MAV programme is crucial.

Furthermore, in her examination, Candy went on to say, "Research differs from creative practice: we do research when we seek to augment our knowledge" (2011, p. 34). What makes the work of the CGI industry especially apt as a test bed for knowledge generation is that not only does it result in an artefact of creative practice—in the case of Animal Logic's work, feature film animation and VFX—it also requires that new techniques and knowledge be gained in order for that work to merit the acknowledgement of being pioneering for the wider industry. We recognize the value of this research aspect of the UTS ALA and MAV on two levels: (1) as an opportunity for reflection, it presents worth for an individual practitioner in honing their artistry, and (2) as an artifact or methodology, it presents worth to the field and affords new means for other artists to hone their artistry.

As we have outlined when addressing the ethical and theoretical challenges, a set of enacted principles (now made explicit) shaped the emerging educational design of the MAV. As we continue seeking insights into ways to successfully support collective learning, we now recognize the power of undertaking a design-based research approach which provides ways of combining theory development with pragmatic innovation in education. In the words of the Design-Based Research Collective (2003, p. 7):

> The intention of design-based research in education is to inquire more broadly into the nature of learning in a complex system and to refine generative or predictive theories of learning. Models of successful innovation can be generated through such work—models, rather than particular artefacts or programs, are the goal.

Through our collaborative research, we are working to generate collective learning models and develop principled case studies that can guide the future development of other transdisciplinary initiatives.

13.7 Conclusion

As we, the co-authors, worked together creatively across practice and education in co-creating the UTS ALA, our collaborative research set out to explicate the nature of the fine-grained investigations needed to yield insights into collective learning. One of the stated aims of transdisciplinarity is to enable mutual learning processes, and as a result, various conceptual models of transdisciplinary research and practice have been developed for use by practitioners in the fields of science, science policy and ecological economics, to name a few (Jahn 2008; Jahn et al. 2012; Lang et al. 2012). Our preliminary study of collective learning suggests that a different orientation is becoming evident in CGI creative practice-education-research collaborations, one that undermines the idea of a universal and normative trajectory of development and step-by-step processes (see also Hill et al. 2014). Emerging from our work, we see instead that it is tuned to complexity sensibilities, ecology and political ecology (Latour 2004; after Forsyth 2008, 2010; Forsyth and Schaverien 2004, 2005).

To be at this point is not unlike being in a dream state where ideas present themselves with clarity though with certain elusiveness, but that is to be expected. As Johnson (2016, p. 13) wrote:

> "Each epoch dreams the one to follow, creates it in dreaming," [Michelet 1839] …. More often than not, those dreams do not unfold within the grown-up world of work or war or governance. Instead, they emerge from a different kind of space: a space of wonder and delight where the normal rules have been suspended, where people are free to explore the spontaneous, unpredictable, and immensely creative work of play.

One of the important goals of the UTS ALA is creating a playful space that aspires to offer each member of the Academy the best year of their life, a year that will unfold in an "ideal world" setting for creativity but provide meaningful learning experiences that develop the grounding needed for future learning and creative growth. This aspiration is mirrored in what the Academy offers industry and the university, for the UTS ALA operates as a shared space where creative practice, education and industry collaborate, experiment, build and play well together.

References

Animal Logic. (2012). *The art of legend of the guardians: The owls of Ga'hoole*. Sydney: Animal Logic.

Animal Logic. (2014). *Showreel*. https://vimeo.com/88968023. Accessed 6 July 2017.

Axelrod, R., & Cohen, M. (2000). *Harnessing complexity: Organizational implications of a scientific frontier*. New York: Basic Books.

Bergmann, M., Jahn, T., Knobloch, T., Krohn, W., Pohl, C., & Schramm, E. (2012). *Methods for transdisciplinary research: A primer for practice*. Frankfurt: Campus Verlag.

Candy, L. (2011). Research and creative practice. In L. Candy & E. Edmonds (Eds.), *Interacting: Art, research and the creative practitioner* (pp. 33–59). Oxfordshire: Libri Publishing.

Catmull, E. (2014). *Creativity Inc.: Overcoming the unseen forces that stand in the way of true inspiration*. London: Transworld Publishers.

Davis, B., & Sumara, D. (2006). *Complexity and education: Inquiries into learning, teaching and research*. Mahwah: Lawrence Erlbaum Associates.

Forsyth, L. (2008). *A learning ecology framework for collective e-mediated teacher development in primary science and technology.* PhD dissertation, University of Technology Sydney.

Forsyth, L. (2010). Understanding networked collective professional learning as a fitness landscape. In J. Herrington & C. Montgomerie (Eds.), *Proceedings of EdMedia 2010: World conference on educational media and technology* (pp. 1474–1483). Toronto: AACE.

Forsyth, L., & Schaverien, L. (2004). Re-presenting collective learning: A generative way forward. In E. Klamma, et al. (Eds.), *Community-based learning: Explorations into theoretical groundings, empirical findings and computer support.* Proceedings of the international conference of the learning sciences (pp. 24–30). University of California at Los Angeles.

Forsyth, L., & Schaverien, L. (2005). Emergent collectivity: Teachers as interdependent e-designers of professional development in K-6 science and technology. *Journal of In-Service Education, 31*(4), 635–656.

Hill, L., Brandeau, G., Truelove, E., & Lineback, K. (2014). *Collective genius: The art and practice of leading innovation*. Boston: Harvard Business Review Press.

Jahn, T. (2008). Transdisciplinarity in the practice of research. In M. Bergmann & E. Schramm (Eds.), *Transdisziplinäre Forschung: Integrative Forschungsprozesse verstehen und bewerten* (pp. 21–37). Frankfurt: Campus Verlag.

Jahn, T., Bergmann, M., & Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics, 79*, 1–10.

Johnson, S. (2016). *Wonderland: How play made the modern world*. London: Macmillan.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science, 7*(S1), 25–43.

Latour, B. (2004). *Politics of nature: How to bring the sciences into democracy*. Cambridge, MA: Harvard University Press.

Miller-Zarneke, T. (2017). *The Lego Batman movie: The making of the movie*. London: Dorling Kindersley.

Plotkin, H. (1994). *The nature of knowledge*. London: Allen Lane, The Penguin Press.

Pohl, C., & Hirsch Hadorn, G. (2007). *Principles for designing transdisciplinary research*. Munich: Oekom.

Pohl, C., Rist, S., Zimmermann, A., Fry, P., Gurung, G. S., Schneider, F., Speranza, C. I., Kiteme, B., Boillat, S., Serrano, E., Hirsch, H. G., & Wiesmann, U. (2010). Researchers' roles in knowledge co-production: Experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal. *Science and Public Policy, 37*(4), 267–281.

Schaverien, L., & Cosgrove, M. (1999). A biological basis for generative learning in technology-and-science: Part I – A theory of learning. *International Journal of Science Education, 21*(12), 1223–1235.

Schaverien, L., & Cosgrove, M. (2000). A biological basis for generative learning in technology-and-science: Part II – Implications for technology-and-science education. *International Journal of Science Education, 22*(1), 13–35.

Scholz, R. W. (2000). Mutual learning as a basic principle of transdisciplinarity. In R. W. Scholz, R. Häberli, A. Bill, & M. Welti (Eds.), *Transdisciplinarity: Joint problem-solving among science, technology and society*. Proceedings of the international transdisciplinarity 2000 conference. Workbook II: Mutual learning sessions (pp. 13–17). Zürich, Haffman.

Scholz, R. W., & Steiner, G. (2015). The real type and ideal type of transdisciplinary processes: Part II – What constraints and obstacles do we meet in practice? *Sustainability Science, 10*(4), 653–671.

The Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8.

Thelen, E. (2005). Dynamic systems theory and the complexity of change. *Psychoanalytic Dialogues, 15*(2), 255–283.

Thelen, E., & Smith, L. (1994). *A dynamic systems approach to the development of cognition and action*. Cambridge, MA: MIT Press.

Vilsmaier, U., Engbers, M., Luthardt, P., Maas-Deipenbrock, R., Wunderlich, S., & Scholz, R. (2015). *Case-based* mutual learning sessions: Knowledge integration and transfer in transdisciplinary processes. *Sustainability Science, 10*, 563–580.

Westberg, L., & Polk, M. (2016). The role of learning in transdisciplinary research: Moving from a normative concept to an analytical tool through a practice-based approach. *Sustainability Science, 11*(3), 385–397.

Part III
Transdisciplinary Case Studies

Chapter 14
Shielding Indigenous Worlds from Extraction and the Transformative Potential of Decolonizing Collaborative Research

Jason De Santolo (Garrwa & Barunggam)

14.1 Introduction

In the lead-up to the October 2014 protests in Borroloola against the proposed zinc mine at McArthur in the Gulf of Carpentaria, many of us painted up with markirra (or white ochre), as is customary for dance and war. The Elders felt this was a necessary statement and an expression of the power and resilience of our culture. Where we source markirra is a very special place and it was under direct threat from the proposed mining project. Elder Nancy McDinny painted this site to talk about its significance and to tell the story of how it is special and why the site needed to be protected against mining. If this site is damaged we may lose the ability to paint up according to the old ways. Many of the Garrwa families were painted up with Ngabaya markings, the markings of a powerful spirit being song tradition. The protests were highly effective. They blocked the roads and demonstrated the power of the four united clans of the region. The protests sparked a new era of awareness for the 'Ngirakar bununu' - shielding cultural powers of 'Garrwa Jungkayi, Ngarra Ngarra Darrbarrwarra' - ancient Garrwa guardianship and eternal good warriors.

Like other Indigenous peoples around the world, the Garrwa have been at the forefront of the resistance to extractive industries since the beginning of time (Gibson 2014). Our languages and song traditions have played a significant role in the protection of the homelands of the Garrwa and the other three tribes/clans of the South West Gulf. They were used in the processes of reclaiming homelands through land rights and native title regimes. Our ceremonies are bound by language and song. Communicating power through language and song is not a new idea and has always been a key to asserting the intent of the Garrwa people. Storytelling is a key pedagogy for intergenerational learning, in both song and dance—our stories are

J. De Santolo (Garrwa & Barunggam) (✉)
Jumbunna: Institute for Indigenous Education and Research,
University of Technology Sydney, Sydney, Australia
e-mail: Jason.DeSantolo@uts.edu.au

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_14

kept alive. Through storytelling, Elders such as Jacky Green, Nancy McDinny and Stewart Hoosan offer visual narratives to shed light on the region's continual resistance against exploitative practices. Many of their paintings tell of Garrwa, Yanyuwa, Mara and Gudanji family mobilizations to protect sacred sites, lands and waters, in keeping with ancient laws.

Elders have also asserted their power by maintaining control over the way stories are filmed. The landmark documentary *Two Laws* (Cavadini and Strachan 1981) told the story of injustice in a 'proper way' that still resonates with the community today (De Santolo 2008, 2014a). In the making of *Two Laws* the Elders ensured that they had control of the production processes as co-producers, effectively creating a paradigm shift in documentary making (Ginsburg 2008). This experience set a benchmark for some Garrwa Elders who now approach knowledge sharing collaborations with caution, especially if they do not feel in control or respected in the process.

Colonization and the extraction of Indigenous resources extends to include the exploitation of knowledge and culture. Increased government, NGO and academic interest in the Indigenous roots of ecocentric thought and sustainability practices has also intensified the demand for access to, and use of, these sophisticated knowledge systems. This is happening all over the world. In Australia, it appears to be occurring in a number of research and creative contexts due to a newfound interest in Indigenous 'things'. It is alarming that this continues to happen despite the fact there is no longer any excuse for conducting research in a purely Western framework.

A project with an Indigenous research paradigm, a significant Indigenous Nation Building research project (INB Project), has recently been launched. In the course of its groundbreaking work with the Gunditjmara, Ngarrindjeri and Wiradjuri Nations, the INB Project has uncovered some alarm bell moments:

> Ultimately, 'colonized' research may be both ethically and intellectually compromised. Its techniques and approaches objectify Indigenous peoples; deny Indigenous peoples' agency as researchers; entrench racist misrepresentations, stereotypes, and attitudes; devalue Indigenous cultures, viewpoints, ideas, and institutions; and appropriate information that Indigenous peoples, generated or shared. (Vivian et al. 2017a, p. 51).

Decolonizing research is a key to shifting these practices within the academy, where despite the best of intentions, there continue to be misrepresentations, recontextualizations and commodifications (albeit often unconsciously) of Indigenous knowledges and resources. Decolonizing research is a sensitive and political venture as it often involves communities of interest that are positioned as allies and collaborators (Janke 2009a, b; Behrendt 2016; Kress and van Leeuwen 2006). This is why Indigenous theoretical frameworks, decolonizing methodologies, Indigenous Storywork (Archibald 2008) and Indigenous Cultural and Intellectual Property (ICIP) rights and protocols are critical in formulating collaborations and strategies involving knowledge sharing and the protection of ecosystems (Smith 2015; Rigney 1997; Nakata 2007; Moreton-Robinson 2015; Archibald 2008; Janke 2009a, b; Pihama 2015; Jackson 2012; Vivian et al. 2017a, b). If certain parties aim to protect living ecosystems through campaigns or collaborations, then these decolonizing frameworks offer a holistic approach for aligning with Indigenous aspirations for self-determination.

Indigenous theories of change and renewal have emerged from urgent needs to liberate people from colonial projects, and to shield lands from exploitative practices. These frameworks harmonies ways of working together, ensuring communicative mapping for longer term goals of Indigenous self-determination and maximum autonomy. For Garrwa Elders, shielding the land from damage is also about communicating sustainable autonomy as an overt challenge to extractive industries in the Northern Territory—where exploration licenses cover 84.9% of the entire landmass (Energy and Resource Insights 2016; Mudd 2016; Hoosan 2014; Kerins 2014). Our own languages, story practices and laws are critical in the fluid and organic expression of these political aspirations. But at their essence lies a profound relational sophistication that has grown with the land over many thousands of years.

This paper sheds light on the nature of Indigenous research and relational collaboration. We unpack the importance of meaning making and truth modalities as analytical elements of a decolonizing framework. Moving beyond outdated understandings of the way we form meaning helps to reveal and unlock the transformational power of revitalizing Indigenous languages. I then ground these foundational notions of Indigenous theorizing through a real-world study of Gulf clan resistance to extractive industries. A specific anti-fracking campaign is highlighted as a means of revealing the key Garrwa principles and practices underlying a sustainable autonomy shielding strategy. This study hints at the potential for unlocking the profound songline logic and the resilience of ancient song traditions as shielding ecologies for protecting sacred sites and sustaining life across social, cultural and political spheres. Song traditions are of high significance for the Garrwa and the other three tribes/clans of the South West Gulf. I then extend this articulation of Garrwa worldmaking ecologies into the realm of creative practice. This analysis is driven by a Garrwa study that reveals how song traditions hold dynamic story world principles and practices.[1] The study offers epistemological insights into the story world principles contained within these songs and illuminates the synergies between ancient Garrwa guardianship roles and sustainability movements. Within the scope of this paper I share an emergent *Yarnbar Jarngkurr* framework for talking, storying, and enacting transformative knowledge ecologies as sustainable shielding strategies. I elaborate on two specific foundational alignments for *Yarnbar Jarngkurr* as it sits within a creative Indigenous methodology: relational being and the enactment of intent.

[1] I am currently undertaking a UTS Doctorate of Creative Arts titled ‘Towards understanding the renewal of ancient song traditions through participatory video practice’. Please note that Garrwa is not a written language and that spelling has been guided by Elders who are fluent speakers and have some linguistic experience. However, I recognise there may be different spellings for words and phrases and that there may be shifts in the spelling at part of the revitalisation of the language.

14.2 Committing to an Indigenous Research Agenda

Indigenous knowledge is deeply tied to the land and to a relational way of being in the world. In fact, the emergence of knowledge is a part of our creation stories, so in many instances it holds deep significance and is mediated through our own original laws as sacred stories and spaces. The idea of research is not a new thing for Indigenous people. Our sophisticated systems and understandings of the living world have come about over many thousands of years of theorizing and practising, testing and reflecting (Pihama 2015). So much so that these ways of understanding offer profound insights for addressing some of the environmental and social challenges we face in contemporary society. Universities, researchers and educators have huge collaborative potential to enact social justice for our communities. For this potential to be realized, collaborators need to be committed to the longer-term agendas of Indigenous partners within research projects. These may be driven by the defence of the rights of Indigenous groups or specific campaigns for the protection of their homelands—it all depends on the context.

The need to delve into this understanding as a researcher is part of being conscious and connected to the world of the research partner. In Indigenous research, communicating in a meaningful and respectful way involves taking steps to consult, and it involves articulating the potential of research to be a tool that promotes transformation and the sharing of knowledge, and of the benefits this can bring. Everyone should gain from the exchange, and this should be done in line with the relevant ethical frameworks. Conceptualizing the meaning of the research is a key part of the consultative process, and it involves a considered understanding of the nuances of cultural context for the Indigenous partners, and of their political realities and aspirations (De Santolo 2015).

Engaging with experienced Indigenous researchers or teams is often the only way to navigate these complexities and protocols in the timeframes imposed by funding bodies or research institutions. Many Indigenous research centres were established to do just that, as part of a broader social justice strategy, as part of a broader strategy for ensuring social justice for families, clans, tribes, organisations and collectives. The Jumbunna Institute at UTS has grown into a world leading research team with a deep desire for social justice and sustainability, but at its heart we hold and cherish strong relationships with communities. Reflecting on the Rates of Crime Project, Jumbunna researchers acknowledge the challenges of operating in 'theoretical spaces' that are emerging in the Australian context, with examples such as Indigenous Standpoint theory (Nakata 2007) and Indiginest Research (Rigney 2001). This reflection recognizes the global leadership of Linda Tuhiwai Smith and others in the development of Kaupapa Maori, and in the decolonizing methodologies space (Smith 2006). Jumbunna Researchers articulated a set of general methodological characteristics: "An emphasis on Indigenous needs and priorities; An emphasis on the development of personal relationships with research participants (not data collection); Research which seeks to be collaborative; Research which honours Aboriginal social mores and cultural protocols; Research which is conducted in the community, for the benefit of the community and with the community" (Vivian et al. 2017b, p. 81).

Indigenous research centres such as Jumbunna have a role in connecting building and mediating relationships, and creating space, frameworks and collaborations that are committed to an Indigenous Research agenda. The Indigenous Nation Building project (INB project) has conducted important analysis of existing Indigenous research methodology literature, and has identified the following key principles and characteristics:

> Support Indigenous community self-determination; Promote an Indigenous version of social justice; Respect Indigenous peoples' agency and humanity; Respect Indigenous knowledge in theorizing and in research design; Support Indigenous communities in reclaiming knowledge, language, and culture; Recognize the greater potential for learning; Reject the minimal 'protect-the-institution' model of research ethics; Seek to transform research institutions". (Vivian et al. 2017b, pp. 52–55).

This analysis maps important considerations for determining how research projects are aligned with an Indigenous research paradigm. But what defines respect in research design? How realistic is it to expect institutional transformation when the research is constrained by institutional parameters? These are complex questions to consider as part of broader discussions. The INB project has tackled some of these concerns by initiating longer-term institutional interventions, including the enactment of clauses that protect cultural knowledge and the creation of community-controlled mechanisms for transforming ethics approval processes (Vivian et al. 2017a, p. 67). The reframing of institutional processes is part of a highly effective decolonizing approach. The INB project identified acknowledges "Aboriginal nations' sovereignty and their inherent right to self-determination" as the most important factor in framing and positioning "all interactions, modes of inquiry, protocols, and interests" in the evolving research project (Vivian et al. 2017a, p. 72).

As this is a fluid and organic realm, unique principles and characteristics are sure to emerge for each project, or as reflective iterations within longer-term strategies. Indigenous research institutes also mobilize relational spaces within the academy for Indigenous scholars to operate in, so that they are not just part of an 'Indigenous-led' project that is potentially framed, housed and controlled elsewhere. These spaces subvert the hierarchies of the tiered lecture theatre as Linda Tuhiwai Smith notes: "The pedagogy of talk is framed by the space we are in" (Smith 2014). The notion of talk also moves us into the more profound aspects of relational being in country and speaking for country. The Ngarrindjeri people of southern central Australia led this movement towards methodologies of transformative engagement as part of nation building, and they have communicated these values within the INB project context. The Ngarrindjeri Regional Authority emerged as a response to colonial governmentality and the aspiration to overcome domination. The Authority embodied a strategic methodology: "At its centre is the Ngarrindjeri concept of *Yannarumi*—broadly translated as 'Speaking for country'. Resulting interaction then reinforces Ngarrindjeri nationhood and agency in protecting Ngarrindjeri lands and waters, by sharing in knowledge production that respects rights to cultural knowledge as a form of intellectual property" (Hemming et al. 2017, p. 23).

Indigenous researchers and units are not embodied solely within the institution; we actually exist through our relationships in the real world. So, it makes sense that at a fundamental level our work is about reasserting the truth of our power through our own stories. These stories are often about collective thinking and survival. Some ancient song traditions hold profound lessons for maintaining a balance and harmony with the natural order. Many of the research stories emerging now are also about survival, but within different realms and systems that were not present before colonization. These stories often have a clear political intent, say for example through an unequivocal mandate to strive for true self-determination—a self-determination that is in line with our own cultural understandings and political aspirations. In the absence of a treaty, the United Nations Declaration on the Rights of Indigenous Peoples is a good basic baseline for self-determination in Australia.

In Australia, each tribe or clan generally holds significant discrete interwoven expressions of knowledge, language, law and practice. Across the regions, there are however different histories and impacts of colonization. Even though there are similarities in our ways as Indigenous peoples, it is important not to rely on generalized notions and principles alone when framing collaborations. Speaking from a Garrwa position, we still hold ancient laws and ceremonies, and with that a profound connection and authority within our world through the *kujika* and the continual enactment of what we could term a songline logic. *Kujika* are like scriptures; they hold immense creation powers as ecological and biological repositories and they involve a profound mapping of the land through the super vital language of the songlines (Bradley 2010, p. 251). This is a very old way of understanding and theorizing the world, a world that has been under immense threat since the violent colonization of Garrwa territories around 200 years ago (Roberts 2005). As Garrwa leader and activist Gadrian Hoosan explains, the importance of keeping culture alive is the foundational aim of Garrwa autonomy:

> When the white people came to this country, we had our own autonomy. We had our own laws and our leaders. Our ancestors went through so much, a history of being treated cruelly, or shot. But our ancestors have kept this culture alive, and now our elders they pass it on to our kids. If we lose that, we are nothing. (Hoosan 2014)

As an emerging framework of principles *Yarnbar Jarngkurr* offers transformative potential for enacting the relational songline logic as a specific aspect of Garrwa Elders' intent to revitalize language.

Working beyond the notion of disciplines is often hard to articulate from within the academy. When we collaborate and bring in others it is often driven by an established trustful relationship that aligns with the specific research task or agenda, and not necessarily a disciplinary alignment. The holistic approach taken within Indigenous research paradigms involves a constant synergizing of knowledge, theory and practice into a transformative in situ energy that we carefully harness with intent and an openness to new ways of conceptualizing meaning.

14.3 Decolonizing Research and Meaning Making

This is an age of new writing where the recognition of the inequalities of communication power and perspective are understood as part a more conscious movement for change and social justice. Talking in our own languages is a political act in Australia, where the educational policies in the Northern Territory outlawed bilingual models of teaching in the mid-1990s.

The idea that different cultures find meaning in different ways is not really in question; rather, what needs to be interrogated are unequal power relations within the colonial project. We need to change the way we analyses and conceptualize meaning as it sits within dominant communication paradigms (van Leeuwen 1999). This is proving to be a difficult task especially in light of the constantly shifting media landscapes and the hierarchal bureaucracies that drive those media. These landscapes are now highly pervasive and influential through social media.

At the same time, we are witnessing a renaissance in storytelling and teaching, originally framed by Jo-Ann Archibald as Indigenous Storywork that is vibrant, relational and deeply connected to the land (Archibald 2008; Lee-Morgan 2015; Wyld and Fredericks 2015). This renaissance is not just about revitalizing Indigenous languages through a reinvigorated understanding of our own epistemologies and ontologies. Decolonizing research methodologies are also fundamentally about liberation and the striving for self-determination. This is also evoked through deep self-reflection and an analytical struggle to maintain disciplinary relevance, as perhaps witnessed in the critiques of the ontological turn. Is there really a question here? Do we as 'native thinkers' have a role in the translation of our own experiences in the world as cultural artifacts (Salmond 2013)? There are multiple reasons why we do and should—but one clear strategy here is the pressing need for a decolonizing framework to map research processes as a journeyed experience into meaning making. If our truths are held within the land and through our languages, then our collaborations must hold true to the modalities that bring to these connections to light. Indigeneity within the academy is about interconnectedness and the liberation of our own semiotic resources that have been tied down and rendered powerless through a colonized lens (Rigney 1997). Subtleties of discourse and language are powerful ways to access different levels of truth, as van Leeuwen notes in his exploration of modality through a social studies textbook chapter on 'Aborigines'. Navigating three voices and representations in a single paragraph van Leeuwen notes the lowest modality is attributed to the 'Aborigines':

> Then, however deeply buried in generalities and abstractions, there is also the voice of the Aborigines themselves, the voice of their truth is called 'belief', rather than, for instance, 'knowledge'. In the dominant discourses of 'our society', 'belief' has lower modality than 'knowledge, 'dream' lower modality than 'reality, and 'religion' lower modality than 'science'. This, too, Australian primary school children must learn, the truths of the Aborigines can be admired as beautiful stories, as dreams, but they are not the kind of factual truth 'we' learn at school. (Van Leeuwen 1999, p. 157)

Research has in the past relied heavily on writing as the dominant way to show authority over a topic, and as a way to conceptualize meaning. Western knowledge paradigms are traditionally categorized and placed in disciplines, and they are hierarchal in nature. Yet it seems many scholars still grapple with the fundamental limitation of the Eurocentric gaze, but not many acknowledge this consciously. Writing perhaps created enough separation from knowledge to make it easier to appropriate and assimilate it. This ethos is changing within the academy through Indigenous theorizing, decolonizing methodologies and other shifts and transdisciplinary thinking that poetically inspires a (trans)forming of being (Gibbs 2017, pp. 54–55). This is fracturing the illusionary power of disciplined knowledge, writing and the dominant modes of communication. Yet writing is very much a shifting practice today. From being a skill that was possessed only by the elite classes and scholars and religious leaders, it has now become something that is highly networked and socialized into a kaleidoscope of multimodality. Trying to avoid the limitations of positivist thinking in the academy is harder than we think, especially if we continue to categories and code and discipline knowledge pathways as if higher learning only takes place within the four walls of the academy. These systemic attributes arise from the institutionalization of knowledge and a clear motivation to control, harness and exploit that knowledge (or process) for profit. If one is to experience knowledge in a real-world sense, we must understand its meaning in terms of its resonance with the people, land and the multiverse. Shawn Wilson articulates the important idea of relational validity and being within Indigenous worlds: "We are not just in relationships; we are relationships" (Wilson 2016). Indigenous knowledge, and therefore research, is conceptualized through its relational context, and is often communicated as a storied journey towards connection and collective meaning making:

> Research is really simple, it is how we engage in knowledge, creation and production, how do we make meaning? We make meaning by being in the community. You don't make meaning as isolated units. You make meaning in the community. And how to we make Indigenous meanings. We make Indigenous meanings by being in Indigenous communities. (Smith 2017a, b)

The legitimacy of the colonial project survives only through mythmaking, for example through the perpetuation of the false assertion that Indigenous peoples are without sophisticated laws or systems for survival and are therefore savages. The system we live in still marginalizes our voices and our authority over ourselves through clever semantics that destroy, hide or diminish the storied truth of our power as Indigenous peoples. These marginalizing messages are often expressed using emotive imagery that is overt in its tone and effectively oppressive in nature.

A good example of this is the Northern Territory Emergency Intervention (NT Intervention) where apartheid-style signs were erected in 2007 at the borders of Aboriginal homelands. These signs outline what can and cannot happen in these homelands according to Western law. To implement the NT Intervention, the government had to suspend the application of the Racial Discrimination Act as it was in direct violation of its purpose, to protect particular races from discriminatory behaviour (Nicholson et al. 2012). The story of child abuse that the government used to justify the NT Intervention was pushed through mainstream media—and later exposed as fraudulent and manufactured (Brull 2017).

Public perceptions are driven so much by the media that many people are brainwashed into thinking Indigenous peoples need saving, and that we are a subservient, lesser type of human compared to the Westerner. We all suffer from the negative impacts of these oppressive media portrayals Despite years of campaigning against the racist policies of the NT Intervention it continues to have effect—indeed, it is in its tenth year of fraudulent operation. The NT Intervention was first initiated and asserted by rolling in the Australian army. This has been highly effective as an intimidation tactic and today we see around 85% of the Northern Territory under mining exploration licenses.

A lot of people don't know this, and/or don't believe that an apartheid-style system is running in Australia. Tribes and clans in the Gulf country have suffered immensely under the NT Intervention. Mobilizing around these struggles involved giving authentic voice to the testimonies of those that are affected. A decolonizing research strategy empowers voice. The emergent *Yarnbar Jarngkurr* framework distinctly enacts Garrwa testimonies as part of a transformative circular praxis (Smith 2017a, b). Quite simply, Garrwa Elders like Jacky Green, Nancy McDinny and Stewart Hoosan want to see their family way of life remain intact and our languages revitalized. Garrwa Elders are leading the revitalization of languages and research strategies within this fluid framework as part of resisting domination as part of a global Indigenous struggle (Pihama 2015).

Research collaborations must therefore understand and strategically engage meaningfully with Indigenous worldviews and aspirations. But for now, what can we learn from the Garrwa homelands movement and the research and environmental activist alliances? This returns us to the two key alignments integral to understanding Indigenous worldviews and world making practices from within a research context. The relational way of being in the world is the first foundational element. The second is the purposeful enactment of Elders' intent as expressed in original Garrwa laws for harmonious sustainable life. These two processes are learnt as part of the family way of *Yarnbar Jarngkurr*—as children we talk and grow into being through a storied understanding of the world. For the purposes of this paper, we discuss and contextualize these two elements as they manifested through the October 2014 protest sites in Borroloola.

14.4 Enacting the Elements: Relational Being and Elders' Intent

Garrwa society is deeply relational, and our place in the world is mediated through powerful talk, story, song and dance traditions. In terms of orientation and alignment, there are key insights provided through the recognition that all knowledge is generated through journeying on the land, whether that is a creative process or a learning from family or a more profound experience (Hoosan 2014; Cayete 1994). The ceremony of knowledge is still deeply personal and relational for those that seek a deeper interconnectedness with Indigenous knowledge systems. As Indigenous researchers, we are constantly navigating the complexities of sharing knowledge within academic constructs that don't always align with this worldview. Storytelling traditions hold and share knowledge in a relational way. Elders hold deep storytelling responsibilities and practices as a way to contextualize their intent in different contexts. In this discussion, the October protests provide insight into the role of talk and storytelling as they manifest through proverbs, paintings, songs, and dance.

Elder Nancy McDinny's proverb, quoted at the beginning of this paper, offers insight into Garrwa values and aspirations for peaceful lives and healthy country. The historical context influences this discourse, as Garrwa are notorious as rebels and fierce defenders of their lands and the region. In 2014 there was a lot of anxiety and concern for the land, as the encroachment of fracking companies was starting to take shape through meetings in Borroloola that were facilitated by the Northern Land Council (NLC).[2] There were also NLC and Sacred Site Authority contract anthropologists, who were visiting communities and making bold claims that roading and piping infrastructure would be going through the heart of Garrwa territory, no matter what the Elders or traditional owners wanted. Witnessing this intimidation was painful and illuminating. Yet it was part of the motivating context for the mobilization of Garrwa Elders and it refocused talk around protecting and staying in country.

Elder Nancy McDinny's proverb also helped to assert authority over the land through the use of Garrwa language as a protest agenda—as language and story authenticates the connection and belonging to the land. Allies have a deeper understanding of Elders' intent and hear the language and realize that the campaigning has emerged from a deeper place, the grassroots. Campaign leaders such as Lauren Mellor honoured the importance of the use of language as a shielding ecology through using it in the materials and media strategies. Allies such as the Environment Centre NT, Lock the Gate and the Environmental Defenders Office were able to draw upon Garrwa language and practices as part of the conscientizing of their teams, their supporters and the protest movement against fracking and extractive industries. The proverb expresses a deep sense of relational being within the land, and offers a gateway into *Yarnbar Jarngkurr,* the talk and story of the land. In effect, it sparked a more inclusive way to articulate struggle, and was a moment of transformation for the Elders who saw Garrwa language and story reflected back to them as a valid and important framing for resistance.

Sitting behind *Yarnbar Jarngkurr* are grounded family practices and protocols. At a basic level they involve storytelling, song and dance and the colourful practices that shape Garrwa storyworlds. Painting on canvas carries the Elders' intent, even though it is a new Western format. It is therefore still mediated by original laws of

[2] This was driven by a number of different interests and companies like Armour Energy. For more context, please refer to http://dontfracktheterritory.org/community/borrol/

storytelling. It holds unique meaning making elements and qualities such as colour, orientation, symbolism, resonance and perspective. In the lead-up to the October protests, Elder Nancy McDinny was concerned about Markirra, the white ochre Kangaroo dreaming site. Markirra is a sacred place, and as noted, was directly being targeted by the infrastructure push of extractive industries around fracking. She offered up a painting of this site, as a story explaining why Elders were concerned with the plans to create a road for mining access to our lands. It was used as an image for a poster publicizing a series of protests in Borroloola against fracking and the impacts of the nearby McArthur River Mine. The poster related to the textual element of the proverb, which related to the land, and the Elders' determination to protect it. The painting was able to show Garrwa agency and guardianship roles and functions of the sites of significance—all without giving away exact GPS coordinates or providing a literal translation. This allowed for a more meaningful protest discourse to emerge, which was relational and based on some of the important responsibility frameworks as held within Garrwa law.

The painting provided a representation of the land and the people and the intent with which these protest actions were enacted. It transcended the usual limitations of literacy and access for local peoples, and provided a visual reference for the protests that tapped into the transferability of multimodal modes of communication. At another level it helped in the meaning making process for local people in Borroloola—many of whom did not have access to the Internet and the protest flyers that were sent around. Painting is part of the guardianship ethos and is appreciated deeply as part of the storytelling tradition in the region.

The history of the Borroloola art movement is very much a political story (Green et al. 2016). Painting provides an interesting translational mobility to storytelling contexts for Garrwa Elders. Painting is a tool that Garrwa leader Uncle Jacky Green uses to share complex notions of impact and resistance. Beyond that, painting has mediated his powerful voice, leadership and language into social and political spheres of influence that are usually dominated by Western writing with its constraints and hierarchies. He has used painting to show the creation story of the place and his outrage at the continual impacts of the McArthur River Mine on the wellbeing of the people in the region.

> [Looking at painting] Like I said early part on, it's part of the whole rainbow snake, and if you look very hard there, I did add some painting of some people at the bottom here, standing, watching over … and if you see over here, I still paint like an eye for that rainbow snake, still watching over today what they're doing to that land—it's getting bigger and damage. (Green, AIATSIS 2016)

Painting has involved long-term collaborations between Jack Green and Sean Kerins, and has generated sharp critiques to development discourses in the Northern Territory (Green et al. 2017). Together, Green and Kerins use paintings as maps and reference markers for articulating the historical trajectories of frontier violence, extraction and colonialism. The use of paintings also imbues a story with fluid multimodal meaning that can then be transferred from a painting to a video, to a webpage, to an opinion piece.

For the Garrwa, painting is a very ancient practice. Many caves are adorned with paintings and stories. Painting is also an adornment. Markirra plays an important role in the marking of our bodies as an expression of who we are and how we relate. So when we 'painted up' using markirra for the October protests we were expressing our relational being in the land and were also evoking the power of the marking and the ochre itself. Many of us took the Ngabaya marking for the protests, and when we marched the Ngabaya dance and song was enacted as an expression of power and authority. The Ngabaya song tradition has emerged as a powerful rallying force for the local community. The local Sandridge Band worked with Elders in the early 2000s to revitalize the tradition by putting part of the public *walaba* song cycles into a bush reggae song (De Santolo 2014b). This song has been very popular to the point that it has become one of the political anthems of the movement to protect homelands in the Gulf. Elder Nancy McDinny worked with her son Gadrian Hoosan and the Sandridge Band in composing the modern track. She describes the Ngabaya as a songline that travels across the continent from West to East through Gulf Country[3]:

> Too many songs that Ngabaya … Maybe in the dreamtime been right around Australia, that Ngabaya been travel …That song is on the land, and it tells you the story about the land, how that Ngabaya been travel through, you know this is from the dreamtime. Dreaming we call the yijan, travel through calling that country name and that Wurdaliya, that Ngabaya been Wurdaliya, that man my grandfather owned it. (Nancy McDinny video interview 2015)

How does this understanding transfer into an Indigenous research paradigm? Once again we return to the simple relational enactment of *Yarnbar Jarngkurr*, and the surge and resurge of Garrwa resistance. There is a fluid and organic flux to being relational within the Indigenous world. To maintain integrity within Indigenous research contexts, what is "important and meaningful is fulfilling a role and obligations in the research relationship—that is, being accountable to your relations" (Wilson 2008, p. 77). For the Garrwa, knowledge is mediated through our original laws, family kinship relations and Elders as senior knowledge holders on country. Moving things through a process of renewal is not something that can be done lightly. In previous research outcomes and processes, the recontextualisation of knowledge has proven to be disruptive and damaging to the Garrwa story and truth.

In contrast, Indigenous-controlled research collaborations are embedding intent as an element of a decolonizing research paradigm. Intent is one of the keys to harnessing the power of storytelling and talking in a transformative research model. Storytelling is such an important way of validation and truth seeking that it also has a particular circular praxis quality that builds inclusive movement through conscientization, resistance and transformation (Smith 2017a, b). Storytelling enables the enactment of intent as driven through a cultural responsibility to the land and to each other, a responsibility that is mediated through original laws and practices.

[3] Ngabaya generally refers to human-like spirit being or spirit people, they are also ancestral beings and a dreaming Bradley, J. 2010, *Singing Saltwater Country: Journey to the Songlines of Carpentaria*, Allen & Unwin, Sydney, Australia.

Decolonizing research methodologies also influence the story context of a protest or campaign. New technologies and networks are driving story ecologies into far wider contexts—exposing the global reach of extractive industries and the interwoven nature of Indigenous self-determination movements.

14.5 Moving Beyond the Elements—Spheres of Influence

Despite all of the best intentions, as researchers we know there are a number of barriers to overcome before harnessing the power of Indigenous research methodologies. Part of this limitation is the inability for research outcomes to transcend heavily entrenched disciplinary silos within the academy. Disciplines tend to privilege different languages and processes. For obvious reasons, this limits the scope of influence for many of us who are seeking transformational change for communities in crisis. Meaningful collaboration is vitally important if we are to overcome some of the systemic barriers to transformational change across different spheres of influence.

As we have discussed, decolonizing research methodologies are fluid and organic in nature. If we reflect on this unique framework, we can reveal methods and practices that may drive new models for transdisciplinary work and collective solutions to complex problems. At the heart of *Yarnbar Jarngkurr* is family, Indigenous language and story. Through this discussion we can offer a number of collaborative research markers that strategically align research practices with autonomous sustainability and aspirations for self-determination. As a short-form consideration of protocols and principles, the following points are rendered as a framework for research practices that are story based. Through this reflection we have also identified some principles of knowledge and storytelling practice that align Garrwa worldviews and values with an aspirational framework for meaningful collaborations:

1. Conceptualizing the meaning of key ideas collaboratively, on country and prior to framing a research proposal.
2. Understanding story contexts and practices as shielding knowledge ecologies and showing commitment to keeping these ecologies as intact as possible.
3. Supporting Indigenous theorizing as a framework for enacting the original laws of the land and Indigenous research leadership.
4. Enacting Elders' intent as family guardianship roles and acknowledging their authority in decision-making.
5. Prioritizing Indigenous resurgence strategies, on the land and through language revitalization.
6. Uplifting and resourcing Indigenous research capacity and creative practices.
7. Building genuine, healthy relationships as part of autonomous sustainability on homelands and in collective communities.
8. Maintaining the relational and generative fluidity of research through transformative praxis and immersive research practices.

9. Respecting the confidentiality of sacred knowledge and spaces and creating Indigenous Cultural and Intellectual Property (ICIP) rights strategies for protecting knowledge generated.
10. Understanding spatial insights, relational reasoning and metadata as being part of the sacred knowledge domain.
11. Recognizing the limitations and dangers of relying on institutional systems for archiving and dissemination.
12. Delivering shared outcomes and benefits in meaningful ways.

This is not an exhaustive list, and the discussion is not all encompassing. I have focused this discussion on revealing how Garrwa enactments of talk, story and song manifest shielding powers within a specific protest site. *Yarnbar Jarngkurr* is still unfolding. Another powerful protest took place outside the headquarters of the Glencore company in Sydney in 2016. The Indigenous youth climate activist collective Seed Mob shone as a key alliance in the protest—which formed part the actions of Garrwa youth to protect country.[4] In this moment we also forged alliances on Gadigal lands with other Indigenous activists and organisations such as Action Aid who offered important resourcing for the action. These moments are important to map, as part of understanding the relational nature of our movements and actions as part of the enactment of Elders' intent to protect country (Fig. 14.1).

Fig. 14.1 Nancy McDinny: Markirra—Global Frackdown protest poster image Borroloola, (2014)

[4]A number of Garrwa youth have take cultural leadership roles in Seed Mob. For more on Seed Mob http://www.seedmob.org.au/our_story

14.6 Concluding Remarks

If our research collaborations aim to support Indigenous movements to protect country from extraction, then they must also align with our truths as they are held within the land. Committing to an Indigenous research agenda allows for the refinement of emergent methodologies, and more importantly, the alignment of research communication strategies with aspirations for Indigenous self-determination. In practice, *Yarnbar Jarngkurr* has application as a communication protocol for specific storytelling mediums such as video, music and design, all of which embody creative realms with the potential to make a genuine contribution to Garrwa liberation.

For now, *Yarnbar Jarngkurr* is emerging as a creative Indigenous methodology and praxis for strategic knowledge revitalization, and for the shielding of homelands from extractive industries. It provides a framework for enacting Elders' intent through a deep understanding of the Garrwa family way of resistance and relational being, while recognizing 'Ngirakar bununu'—the shielding cultural powers of 'Garrwa Jungkayi, Ngarra Ngarra Darrbarrwarra'—Garrwa guardians and eternal good warriors.

As transformative praxis, it continues to evolve, shift and remain responsive to the shifting face of colonialism and neoliberal strategies of extraction. Carefully framed Indigenous research collaborations hold transformative potential to revitalize our languages and contribute to sustainable movements in contemporary life. A conscious transdisciplinary shift would forge deeper understandings of relational being as a collective positioning and continue manifesting interconnectedness through new communicative models of Indigenous storywork, autonomous sustainability and healthy living.

References

Archibald, A. (2008). *Indigenous storywork: Educating the heart, mind, body, and spirit*. Vancouver: UBC Press.

Behrendt, L. (2016). *Finding Eliza, power and colonial storytelling*. Brisbane: University of Queensland Press.

Bradley, J. (2010). *Singing saltwater country: Journey to the songlines of Carpentaria*. Sydney: Allen & Unwin.

Brull, M. (2017). A decade on, the fraud of the NT intervention is exposed. *New Matilda*. https://newmatilda.com/2017/06/28/a-decade-on-the-fraud-of-the-nt-intervention-is-exposed/. Accessed 10 Nov 2017.

Cayete, G. (1994). *Look to the mountain: An ecology of indigenous education*. Skyland: Kivaki Press.

De Santolo, J. (2008). Two laws: Notes on resonance, Kanymarda Yuwa/two laws – Special DVD dossier. *Studies in Documentary Film, 2*(2), 185–189.

De Santolo, J. (2014a). *Living with two laws, our stories our way. Broadcast on NITV, 2014*. https://vimeo.com/103872281.

De Santolo, J. (2014b). [online video] *West to east, our stories our way.* Broadcast on NITV 2014. https://vimeo.com/104358468. Accessed 12 Nov 2017.

De Santolo, J. (2015). *Conceptualising research and consultation within a creative doctorate.* International indigenous development research conference proceedings, Nga Pae o Te Maramatanga, University of Auckland.

Energy and Resource Insights. (2016). *The extent of fossil fuel tenements in Australia.* http://data.erinsights.com/downloads/FFinAUS/FF%20tenements%20in%20Australia.pdf. Accessed 5 Oct 2016.

Gibbs, P. (2017). Transdisciplinary thinking: Pedagogy for complexity. In P. Gibbs (Ed.), *Transdisciplinary higher education: A theoretical basis revealed in practice*. Cham: Springer.

Gibson, P. (2014). *Clans unite against fracking in the top end*. https://newmatilda.com/2014/10/12/clans-unite-against-fracking-top-end/. Accessed 1 June 2017.

Ginsburg, F. (2008). Breaking the law with two laws: Reflections on a paradigm shift, Kanymarda Yuwa/two laws – Special DVD dossier. *Studies in Documentary Film, 2*(2), 169–174.

Green, J., Hoosan, G., & McDinny, N. (2016). *Social licence. Flow of voices 3: Jack Green, Stuart Hoosan, Nancy McDinny with Miriam Charlie*, Cross Arts Gallery, Sydney. http://crossart.com.au/current-show/95-2016-exhibitions-projects/300-social-licence-flow-of-voices-3-jack-green-stuart-hoosan-nancy-mcdinny-with-miriam-charlie-29-october-to-26-november-2016. Accessed 10 Nov 2017.

Green, J., Ritchie, T., & Kerins, S. (2017). *Open cut, an exhibition by Jacky Green, Therese Ritchie and Sean Kerins.* Northern Centre for Contemporary Art, 5–28 August 2017, Darwin, Northern Territory, Australia. http://www.thereseritchie.com/art.com/Open_Cut.html.

Hemming, et al. (2017). Speaking as country: A Ngarringjeri methodology of transformative engagement. *Ngiya Talk the Law, 5*(22–46). University of Technology, Sydney.

Hoosan, G. (2014). The land is the most important thing for indigenous people. *The Guardian, 10 October*, 2016. https://www.theguardian.com/commentisfree/2014/oct/10/gadrian-hoosan-the-land-is-the-most-important-thing-for-indigenous-people.

Jackson, M. (2012, May). Panel discussion presentation. *United Nations Permanent Forum, Eleventh Session.* New York. https://www.scribd.com/document/101167246/UN-PFII-Moana-Jackson-Presentation-Doctrine-of-Discovery-6may2012. Accessed Oct 2014.

Janke, T. (2009a). *Writing up Indigenous research, authorship, copyright and Indigenous knowledge systems*. Sydney: Terri Janke & Company.

Janke, T. (2009b). *Beyond guarding ground, a vision for a national indigenous cultural authority*. Sydney: Terri Janke & Company..

Kerins, S. (2014). Aboriginal landowners angry after warning NT mine is poisoning fish, leaking toxins. *New Matilda*. https://newmatilda.com/2014/10/30/aboriginal-landowners-angry-after-warning-nt-mine-poisoning-fish-leaking-toxins/. Accessed 12 Oct 2016.

Kress, G., & Van Leeuwen, T. (2006). *Reading images: The grammar of visual design* (2nd ed.). New York: Routledge.

Lee-Morgan, J. (2015). Decolonising Maori narratives: Purakau as a method, Kaupapa Maori theory: Transforming theory in Aotearoa, Kaupapa Rangahau: a reader. In L. Pihama & K. Southey (Eds.), *Kaupapa rangahau: A reader.* A collection of readings from the Kaupapa Māori Research workshops series. Hamilton: Te Kotahi Research Institute.

Moreton-Robinson, A. (2015). The white possessive: Property, power and indigenous sovereignty. Minneapolis: University of Minnesota Press.

Mudd, G. (2016). *The McArthur River project: The environmental case for complete pit backfill.* Mineral Policy Institute. http://www.mpi.org.au/wp-content/uploads/2016/08/The-McArthur-River-Project-The-Environmental-case-for-Complete-Pit-Backfill-1.pdf. Accessed 10 Oct 2016.

Nakata, M. (2007). *Disciplining the savages: Savaging the disciplines*. Canberra: Aboriginal Studies Press.

Nicholson, A., Watson, N., Vivian, A., Longman, C. D., Priest, T., De Santolo, J., Gibson, P., Behrendt, L., & Cox, E. (2012). *A response to the NTER stronger futures consultations June to*

August 2012. Jumbunna Indigenous House of Learning. https://www.uts.edu.au/sites/default/files/ListeningButNotHearing8March2012_1.pdf.

NITV. (2014). [online video] *Global frackdown in Borroloola: Top end clans unite against fracking.* Available at: https://www.youtube.com/watch?v=dYmX9YEWmUA&feature=youtu.be Accessed 12 November 2017.

Pihama, L. (2015). *Kaupapa Maori theory: Transforming theory in Aotearoa, Kaupapa Rangahau: A reader* (Pihama L., Tiakiwai, S.-J. & Southey, K. Eds.). Hamilton: Te Kotahi Research Institute.

Rigney, L. (1997). Internationalization of an indigenous anti-colonial cultural critique of research methodologies: A guide to indigenist research methodology and its principles. *Journal for Native American Studies, 14*(2), 109–121.

Rigney, L. (2001). First perspective of indigenous Australian participation in science: Framing indigenous research towards indigenous Australian intellectual sovereignty. *Kaurna Higher Education Journal, 7*, 1–13.

Roberts, T. (2005). *Frontier justice: A history of the Gulf country to 1900*. Queensland: University of Queensland Press.

Salmond, A. (2013). Hau. *Journal of Enthnographic Theory, 3*(3), 1–32.

Smith, L. T. (2006). *Decolonizing methodologies*. London: Zed Books.

Smith, L. T. (2014). *Keynote: He Manawa Whenua.* [online video] Te Kotahi Research Institute, University of Waikato. https://www.youtube.com/watch?v=BUm3DVsek-I.

Smith, G. H. (2015). *The dialectic relation of theory and practice in the development of Kaupapa Maori Praxis*. Hamilton: Te Kotahi Research Institute.

Smith, G. H. (2017a). *He Manawa Whenua.* Presentation: Te Kotahi Research Institute, University of Waikato.

Smith, L.T. (2017b). *Keynote: Stories of indigenous resistance. Native Organization of Indigenous Scholars*. The 16th annual symposium of Native and Indigenous Scholarship, University of Washington, Seattle.

Two Laws. (1981). [16 mm film] Directed by Strachan, C. and Cavadini, A. Borroloola Aboriginal Community, Northern Territory, Australia.

Van Leeuwen, T. (1999). *Speech, music, sound*. London: Palgrave Macmillan.

Vivian, A., Jorgensen, D., Bell, R. D., Cornell, S., & Hemming, S. (2017a). Implementing a project within the indigenous research paradigm: The example of nation building research. *Indigenous Methodologies: Ngiya Talk the Law, 5*, 47–74.

Vivian, A., Porter, A., & Behrendt, L. (2017b). Reflections on the rates of crime project. *Indigenous Methodologies, Ngiya Talk the Law, 5*, 75–99.

Wilson, S. (2008). *Research is ceremony, indigenous research methods*. Nova Scotia: Black Point, Fernwood Publishing.

Wilson, S. (2016). Using Indiginest research to shape our future. In Gray et al. (Eds.), (2016) *Decolonizing social work*. New York: Routlege.

Wyld, F., & Fredericks, B. (2015). Earth song as storywork: Reclaiming indigenous knowledges. *Journal of Australian Indigenous Issues, 18*(2), 2–12.

Chapter 15
Collaborative Research and Action: The Changzhou Worker Wellness Project

Linda Neuhauser, Xiaodong Wang, Yun Hong, Xiaoming Sun, Zhanhong Zong, Xingyu Shu, Jingshu Mao, Eve Wen-Jing Lee, and Sono Aibe

A major worldwide challenge is to understand and address highly complex problems, such as poor health, poverty and environmental degradation. A powerful way to do so is to integrate and implement knowledge across multiple disciplines and sectors, a process called "transdisciplinarity." Using transdisciplinary approaches is difficult, because university teaching, research institutions and practice organizations all tend to have disciplinary specialization. However, since the emergence of transdisciplinarity in the mid-1900s, we now have not only a solid theoretical foundation to guide this work, but also a growing number of real-world transdisciplinary efforts to enhance our collective learning.

This chapter is intended as a companion case study to the chapter in this book entitled: "Practical and scientific foundations of transdisciplinary research and action" (Neuhauser 2018, Chap. 3 in this book), which describes the pragmatic and theoretical roots of transdisciplinarity. This chapter provides a brief summary of the scientific foundation of transdisciplinarity and focuses on the design and implementation of a transdisciplinary project. We have four objectives for this chapter:

L. Neuhauser (✉)
School of Public Health, University of California, Berkeley, CA, USA
e-mail: lindan@berkeley.edu

X. Wang · Y. Hong
Changzhou Health and Family Planning Commission, Changzhou, China

X. Sun · X. Shu · J. Mao
School of Sociology and Population Science, Nanjing Youdian University, Nanjing, China

Z. Zong
School of Sociology and Population Science, Nanjing Youdian University, Nanjing, China

E. W.-J. Lee
School of Public Health, Health Research for Action Center, University of California, Berkeley, CA, USA

S. Aibe
Pathfinder International, Watertown, MA, USA

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_15

(1) briefly summarize the emergence of transdisciplinarity to address complex problems; (2) briefly describe the scientific foundation of transdisciplinarity; (3) explore a case study of a transdisciplinary project in China; and (4) discuss issues and recommendations about transdisciplinary work.

15.1 The Emergence of Transdisciplinarity to Address Complex Problems

The transdisciplinary movement was directly catalyzed by the realization that traditional approaches have not been effective to address complex problems, as summarized below and in other chapters in this book (Gibbs et al. 2018, Chap. 1 in this book; Klein 2018, Chap. 2 in this book; Ross and Mitchell 2018, Chap. 4 in this book; Prior et al. 2018, Chap. 5 in this book; Nicolescu 2018, Chap. 6 in this book; Gibbs 2018, Chap. 19 in this book). Key weaknesses include: (1) research integration; (2) research translation and implementation; and (3) participatory processes.

15.1.1 Research Integration

Because most researchers work within a limited number of disciplines, it is difficult for those who conduct research and those who apply it, to access knowledge from many disciplines and perspectives (Bammer 2013; Lubchenco 1998). Research studies do not usually consider the fundamental determinants of problems, and many interventions fail (Phelan et al. 2010). For example, research and interventions about factory worker health are often guided by the traditional "medical model" that focuses narrowly on worker access to medical services, rather than on the many other underlying socio-cultural and environmental "determinants of worker health." Key determinants include health knowledge, working conditions, social connections, diet, exercise, relaxation, and ability to manage life issues. There is now a strong movement to explore the many determinants of a problem across disciplinary boundaries and over the "life course" (Halfon and Hochstein 2002; Smedley and Syme 2000; Wilkinson and Marmot 2003; Whitehead 1991). Beginning late last century, new models of research integration advocated bringing together researchers of diverse disciplinary backgrounds to work on complex problems (Bammer 2013; Neuhauser et al. 2007; Best et al. 2006).

15.1.2 Research Translation or Implementation

Another issue is that even when researchers integrate multiple disciplinary perspectives and identify key determinants of a problem, they often overlook engaging with beneficiaries and stakeholders across sectors and resulting interventions do not work in "real-world contexts" (Neuhauser et al. 2007). Jensen (2003) estimated that interventions rarely reach more than 1% of the target population. The "social-ecological model" (Stokols 2006) has now become a widely used framework to translate scientific findings into effective interventions. This model guides those who research problems and those who develop and implement interventions to consider interactions at all societal levels: from individuals, families, neighborhoods, communities and organizations, to broad cultural, political and environmental influences.

15.1.3 Participation in Research and Its Implementation

Another weakness of traditional research for action approaches is the lack of deep participation from researchers, practitioners, policymakers and beneficiaries that affects all aspects of research integration and research implementation (Neuhauser and Kreps 2014; Minkler and Wallerstein 2008). Lack of participation among diverse stakeholders from an adequate number of disciplines and societal sectors makes it harder to get to the root causes of problems, and design effective interventions. "User participation" is often limited to "feedback," of already-designed interventions, rather than true co-collaboration from the start.

Since the mid-1900s, theory and methods of participatory design have emerged from disciplinary roots in social sciences (sociology, public health, etc.) and in socio-technical, or "design" sciences (engineering, architecture, etc.) (Neuhauser and Pohl 2014). Action research and community-based participatory research models emphasize reciprocal cycles of "research for action" and "action for research" and provide important guidance on strategies to create co-collaboration among researchers, implementers, beneficiaries and other stakeholders (Lewin 1946; Reason and Bradbury 2008; Minkler and Wallerstein 2008). Action research, especially community-based participatory action research, generally involves long-term processes of community-researcher engagement, problem identification, reflection and intervention development, implementation and revision. Design science models are also highly participatory, but tend to use rapid, iterative problem identification and solution development methods that engage developers and end users as collaborators.

15.1.4 Transdisciplinarity: A Unified Concept to Address Complex Problems

"Transdisciplinarity" has now emerged as the concept with the best fit to unify research integration and implementation across disciplines and societal sectors with intense participatory processes. There are multiple definitions and models of transdisciplinarity (Gibbs et al. 2018, Chap. 1 in this book; Klein 2018, Chap. 2 in this book; Ross and Mitchell 2018, Chap. 4 in this book; Prior et al. 2018, Chap. 5 in this book; Nicolescu 2018, Chap. 6 in this book; Gibbs 2018, Chap. 19 in this book; Gibbs 2014; Hadorn et al. 2010; Hoffman-Reim et al. 2008; Nicolescu 2010). One example is Pohl and Hirsch Hadorn's (2007: 20) definition:

> The starting point for transdisciplinary research is a socially relevant problem field. Within this field, transdisciplinary research identifies, structures, analyses, and deals with specific problems in such a way that it can:
>
> (a) grasp the complexity of problems,
> (b) take into account the diversity of life-world and scientific perceptions of problems,
> (c) link abstract and case-specific knowledge, and
> (d) develop knowledge and practices that promote what is perceived to be the common good.
>
> Participatory research and collaboration between disciplines are the means of meeting requirements (a–d) in the research process.

Transdisciplinary work is characterized by highly participatory, mixed (quantitative and qualitative) methods that engage researchers, beneficiaries and stakeholders from multiple disciplines and societal sectors from the beginning, rather than in disconnected phases.

15.2 The Scientific Foundation of Transdisciplinarity

In addition to the practical motivation to solve complex problems that led to the transdisciplinary movement, a parallel transformation was taking place in thinking about the nature of reality and scientific inquiry that provides a robust theoretical foundation for transdisciplinarity. Perceived weaknesses in scientific inquiry and its application to addressing societal problems prompted the so-called "scientific revolution" in the mid-1900s (Kuhn 1962). There was a shift away from the view that only one reality (ontology) exists and that it is knowable. A newer perspective is that reality is made up of multiple dimensions, or directions in motion, with neither a beginning nor an end—like the Internet, and that reality is complex, contextual, and ever changing (Deleuze and Guattari 1980; Cook 1985).

Changes in thinking about ontology led to parallel changes in thinking about epistemology, or ways of understanding reality. In this newer perspective, knowledge is "collective," cannot be found through any single discipline, and requires that multiple investigators and stakeholders gradually study phenomena from as many different perspectives as possible, and by using multiple theoretical frameworks, methods, settings and interpretations of evidence (Kahn and Prager 1994; Cook 1985). Such changes in scientific inquiry would be critical to investigate complex 'wicked' problems that are changeable, contextually localized, value-laden, difficult to understand and solve, and which must be constantly reevaluated (Rittel and Webber 1973; Tapio and Huutoniemi 2014). This has contributed to the emergence of new epistemological paradigms.

Until the mid twentieth century, the dominant epistemological "natural science" paradigm assumed that the world is knowable, governed by universal laws and that knowledge can be generalized to multiple settings. This approach to scientific inquiry uses controlled experimental methods and has generally been a good fit for the natural sciences, such as physics and chemistry, but was insufficient to study phenomena affected by human behavior. This catalyzed the emergence of the 2nd major epistemological paradigm: the "human sciences," such as sociology, anthropology, etc. (Dilthey 1998). This paradigm acknowledges that because human phenomena are not as predictable as those in the natural sciences, they must be studied using multiple methods in many settings (Cook 1985).

Both natural and human science inquiry study what exists, but solving complex problems means studying not only the present, but also the *future*—such as the process of developing effective new programs and revising them over time. To address this gap, a 3rd epistemological paradigm emerged in the mid-1900s: the "design sciences" (Fuller and McHale 1963). Design sciences, are concerned "not with how things are, but with how they might be" (Simon 1996, p. 4). In design sciences, researchers and other stakeholders study human-created objects, activities, services and environments to solve problems and meet goals (Buchanan 1992). Design sciences are especially useful to develop and constantly refine health and social interventions. Because the goal of design science inquiry is to solve problems, rather than to test theories, design science methods are highly participatory, qualitative, inductive and iterative (March and Smith 1995). A popular method is "design thinking" in which participants engage in rapid, simultaneous cycles of identifying problems and solutions. See Neuhauser (2018, Chap. 3 in this book) for more information about design science models and methods. All three epistemological frameworks and methods provide useful guidance for solving complex problems and are commonly combined in transdisciplinary work.

15.3 Transdisciplinary Case Study: The Changzhou Worker Wellness Project

In this section, we describe the Changzhou Worker Wellness Project as an example of using a highly participatory, transdisciplinary approach to address the complex problem of supporting migrant workers in China.

15.3.1 Project Background

The People's Republic of China (China) is experiencing one of the largest demographic transitions in recorded history as hundreds of millions of rural residents (migrants) come to urban areas for work—especially in the new economic development zones. It is estimated that there are over 250 million migrant workers. Most of these migrant workers are under 30 years old, have low educational levels (less than high school), and limited understanding of managing life issues in their new urban environment (Lu and Xia 2016; Zhang 2010). They struggle with many challenges such as isolation from their rural families (including their children), depression, infectious diseases and reproductive health problems, and limited educational opportunities. In addition, the vast majority of migrant workers do not have a local *hukou* (official residence registration) in the urban area to which they have moved. Because they are not official residents, these workers often lack access to social security, education for their children, health services, housing and other services—as compared to official residents—and have poor knowledge about how to protect their health and create a stable and positive future.

The Chinese government developed its 12th five-year plan (2011–2015) that emphasizes the improvement of human wellbeing, especially among vulnerable migrant workers with lower education and resources. In 2017, President Xi Jinping announced the ‘Healthy China’ policy intended to provide high-quality health and wellness services for people over their lifetime.

Despite these major policy mandates, China has struggled to find effective ways to support migrant workers. Many traditional “top-down” approaches have not been successful to connect workers with health and social services or promote their health and wellness in other ways. This situation exhibits many attributes of a complex (or wicked) problem in which it is hard to plan in a rapidly changing demographic environment. Problems are sometimes caused by those charged with addressing them (in this case, by conflicting government policies), and problems are difficult to understand and solve without the perspectives of a range of stakeholders including those most affected (Rittel and Webber 1973; Tapio and Huutoniemi 2014). It is, therefore, a complex problem for which a participatory, transdisciplinary approach is recommended.

In 2011, the Chinese government contacted Pathfinder International and the Health Research for Action center (HRA) at the University of California, Berkeley to assist them with the development of a new, participatory strategy to support the health and wellness of migrant workers. Pathfinder International (http://www.pathfinder.org/) is a global non-governmental organization, which since 1957 has been committed to participatory approaches to health interventions, with a focus on sexual and reproductive health. HRA is a center in the School of Public Health at UC Berkeley (http://healthresearchforaction.org/). For over 25 years, HRA has used highly participatory and transdisciplinary approaches to co-design, co-implement and co-evaluate health interventions globally (Neuhauser et al. 2013). Other non-profit organizations contributed to the technical assistance and early start-up costs, including the Levi Strauss Foundation, the Institute for East Asian Studies at the University of California, Berkeley, the Asia Foundation and Oxfam.

15.4 Project Model and Methods

Beginning in 2011, Pathfinder International and HRA partnered with the Chinese government and other stakeholders to develop the Changzhou Worker Wellness Project ('project'). This pilot project is located in the City of Changzhou in the south of Jiangsu Province between the cities of Nanjing and Shanghai. Changzhou has a population of about 4.7 million including over 1.5 million migrant workers. It is one of China's earliest industrial development zones and has a rapid influx of migrant workers. Although Changzhou had created many health and social services for migrant workers, worker participation was very low, due to distrust and lack of information and motivation.

Barriers to getting local resident status (*hukou*) were frustrating to workers who desired high quality education for their children and also a wide array of services. Further, migrant workers felt disconnected socially from their co-workers and from life in the city—leading to isolation and depression. Reports of high rates of unintended pregnancies and high risk for infectious disease were also a concern of factory managers and health providers in the city. And, factory owners and managers worried about difficulties recruiting workers and about high rates of absenteeism and turnover. From the outset, the project adhered to a transdisciplinary approach, drawing on guidance from many disciplines and from stakeholders in many sectors, with intense participation and the adoption of diverse, iterative, qualitative and quantitative methods. Key methods included those in the following sections.

15.4.1 Training Workshops

As mentioned above, a participatory, transdisciplinary approach has not been the norm in China, where decision-making tends to take place at high levels of authority. For this reason, beginning in 2012, we conducted three workshops with key stakeholders (government officials, researchers, service providers, factory owners and managers, media and other stakeholders) to explain the value of the proposed model and secure 'buy in' before the main activities were designed and implemented. These workshops focused on helping stakeholders understand: how to identify key determinants of health for migrant workers; the value of deep participation; results of baseline studies with migrant workers; and ways to identify potential intervention solutions. Although initially uncomfortable with the participatory process, stakeholders quickly began to appreciate it.

Methods used included lectures and discussion about participatory projects with migrant workers elsewhere, and "design thinking" exercises. For example, a design thinking exercise involved covering one wall of the training room with paper and having participants identify migrant worker issues and then pair those issues with ideas to address them. In that exercise, participants identified more than 50 determinants of migrant worker health, and many ideas for interventions. In the two initially participating factories (a garment factory and a computer component factory) workers volunteered to be 'worker leaders' and engage their co-workers to participate in the project and identify problems and practical solutions. Workers described used a variety of methods to engage other workers during non-work hours, such as in dorm rooms or other meeting places. In some cases, factories provided paid time off for worker leaders to conduct these meetings. The workshops and factory discussions were highly productive, resulting in high enthusiasm and confidence among the stakeholders and identification of specific problems and solutions.

15.4.2 Early Engagement with Factory Workers

After the aforementioned stakeholders were trained and invested in the participatory approach and worker-leaders had discussed the project with other workers in their factory, the workers and other stakeholders had their first meetings together. This decision to not include the workers in the initial trainings was intentional. If stakeholders who held decision-making positions (government officials, health and social service providers and researchers) had not yet adopted the participatory approach, they would have been likely to follow the traditional approach of making decisions *for*, rather than *with*, the workers. The first meetings with worker-leaders and a small group of representative stakeholders were held at the factories. At first, the workers were reluctant to bring up wellness issues and ideas for the project—given that they were not used to being asked for opinions by those with more power.

We found that if the workers could identify a few problems and have their solutions adopted quickly, they became confident and participated enthusiastically in the project. For example, at one of the first meetings with workers and other stakeholders, workers asked for computers with webcams so they could communicate with family back in their home town. The factory manager immediately agreed to this request, which then motivated workers to come up with other issues and solutions. At another factory, workers identified the problem of having to travel long distances to take the required yearly health exam in their home town. They asked if they could have the exam in Changzhou instead. One stakeholder present was a national policymaker who, after checking the exact regulations with her national office during the meeting, granted the workers' request. These participatory exchanges modelled the value of "design thinking" strategies that rapidly identify problems and solutions among diverse stakeholders, including those who experience a problem, and those with the power to approve solutions.

15.4.3 Identification of Stakeholders and Establishment of Committees

In transdisciplinary processes, key stakeholders should be identified at the outset and provided with specific ways to collaborate. Project stakeholders included people from diverse disciplines: medicine, public health, sociology, social welfare, employment/labor, psychology, policy, government, education, statistics, government affairs, etc. They also included people from diverse sectors: government, academia, social services, health services, employment services, labor relations, education, private industry (factories), media and non-profit funding organizations. Stakeholders were represented on three committees: (1) Expert Committees of researchers and leaders from health and family planning with a focus on research and policy; (2) Service Committees of service providers and workers to focus on worker information resources; and (3) Administrative Committees of broad-based stakeholders to focus on linkages between factories and government organizations. The Committees brought together researchers, government officials, health and social service providers, factory managers and workers. The establishment of three committees proved to be an efficient and effective way to meet the transdisciplinary principle of engaging stakeholders from diverse disciplines and sectors in society, and at the same time focus their work on specific—rather than *all*—project activities. Representative committee members regularly meet across committees to integrate overall project activities.

15.4.4 Formative Research—Focus Groups

During the first year of the project, Nanjing University of Posts and Telecommunications (Nanjing Youdian University) with the help of Pathfinder International partnered on focus group research to collect baseline information. Nanjing Youdian University conducted 5 focus groups with Changzhou leaders and health and social service providers and 6 focus groups with factory workers. Focus groups explored health and social service issues for migrant workers. Results identified major challenges faced by migrant workers, including: difficulties of providing services to workers who were spread across the city and disconnected from and distrustful of the system; lack of understanding of workers' rights; lack of participation in job training opportunities; lack of housing assistance; lack of social activities and support; lack of access to physical and mental health services and health information (Sun et al. 2012). An area of particular concern was that workers had little understanding of contraception and sexually transmitted diseases, resulting in high rates of abortions. Overall, results showed workers had little understanding about managing life issues in Changzhou.

15.4.5 Formative Research—Baseline Worker Survey

With input from HRA, Nanjing Youdian University conducted a survey with 1114 workers in the two pilot factories to explore worker health and social issues (Sun et al. 2011). Results added to those from the focus groups. Workers expressed concerns about handling a wide variety of life issues, including: understanding their rights; accessing health and social services (few knew about available free health services); learning about health (many had incorrect knowledge about diseases like AIDS); understanding reproductive health and contraception (over 75% did not have accurate information about contraception); preventing unwanted pregnancies (about 30% of women had had an unwanted pregnancy and 22% had had an abortion); and having opportunities to socialize and improve job skills. In addition, interviews with factory managers showed that they were very concerned with worker health issues—especially lack of worker connection with health services, lack of knowledge about positive health behaviors, high rates of unplanned pregnancies and abortions, and high worker turnover rates (sometimes 100% per year).

15.4.6 Problem and Solution Identification

Design thinking methods and worker discussion groups were used to identify problems and solutions from the perspectives of workers and diverse stakeholders. As mentioned above, the design thinking exercises with stakeholders took place during the workshops, resulting in lists of problems paired with ideas for potential solutions. The worker groups led by 'worker leaders' in the factories were a rich source of problem identification and solution generation. As transdisciplinary work on complex problems is a continuous cycle of problem identification and solution generation, these processes have been continuing over time in the factories. We note that as workers and other stakeholders become more comfortable with participatory processes, problem and solution cycles can improve in terms of more rapid decision-making and result in more refined interventions. This process has similarities to the business strategy of "continuous process improvement" (Fryer et al. 2007).

15.4.7 Iterative Intervention Design

The above research methods and stakeholder activities provided a large array of problems and potential solutions over a one-year period. Stakeholders refined priority interventions through the iterative process. Three key interventions emerged: (1) a worker- and expert-designed a low literacy 'Wellness Guide' about managing health and social issues in the local urban environment; (2) 'Wellness Houses'—rooms in each factory where workers could meet to socialize and discuss and solve issues, exercise, and have access to health care, job training and other services; and (3) peer-to-peer worker 'buddy' support systems in which experienced workers would be paired with new workers. Project stakeholders created a short video (in Mandarin with English subtitles) showing the project development, participatory process and interventions: https://www.youtube.com/watch?v=0WvVy1pyDbg

Although these interventions are primary interventions at the participating factories, the participatory process has generated many other interventions which (as described below) vary greatly according to specific factory contexts and also evolve over time. For example, in one factory, after the major intervention components had been implemented, women who were nursing mothers asked for a safe place to breastfeed their infants during work hours. The factory was able to accommodate this request. According to the principles of participatory design, it is the participatory *process*, rather than the specific interventions that is the most powerful part of the approach.

15.5 Project Progress and Findings

15.5.1 Project Scope and Primary Interventions

To date, the number of participating factories has expanded from 2 to 31, with many more interested in joining and government commitment to expand the project citywide. These factories include more than 35,000 workers. In keeping with the project tenets of participatory design, each factory defines its own issues and creates its own Wellness House with worker and manager input. To support expansion and sustainability long-term, the Changzhou government provides some initial funding for furniture and equipment in each Wellness House, and the factory pays the remaining costs, including for upkeep and build-out over time.

Wellness Houses are attractive and comfortable places where workers can socialize, receive training, solve problems, exercise, use the library and computers to find information and connect with families back home. The Wellness Houses are unique and adapted to the particular factory context and worker population. Intense worker input has been critical. In the earlier phases of the project, some factory managers acknowledged that when they shortchanged the participatory process and tried to push their own ideas for the Wellness Houses, their ideas failed. However, after they truly engaged with workers and other stakeholders, the interventions were successful. The project approach was also appreciated by factory managers who had experienced problems before joining the project. One factory general manager reported that his factory had set aside a space for workers to use, but did not know what to do with it until the factory joined the project and staff learned how to collaborate with workers. Once engaged, those workers created a multi-faceted Wellness House that met their needs. In the design of one Wellness House workers identified low literacy as an issue and created literacy training activities. In another factory, workers wanted to address the problem of not having a local summer school for their children—a major factor leading to high turnover. They designed a beautiful children's classroom in the Wellness House, along a high-level curriculum.

During the development of the earliest Wellness Houses, project stakeholders decided to create one logo that would become an icon for all Wellness Houses. A designer developed several options. Interestingly, although professional project stakeholders (government officials and service providers) selected a traditional for-

Fig. 15.1 The Changzhou Wellness House Logo selected by factory workers **("Jian Khang" means "health")**

mal design, workers prevailed with their selection of the modern, positive and whimsical logo shown in Fig. 15.1, that they think represents "workers smiling into the future." Project stakeholders frequently point to the logo with pride and often cite it as an example of the importance of worker input.

The Wellness Guides—the second major intervention—are very popular with over 30,000 copies currently distributed. The easy-to-use Guides (middle school reading level) cover a wide range of topics as suggested by workers, experts, providers and other stakeholders including: health care access, sexual and reproductive health, infectious diseases (such as HIV/AIDS), diet, exercise, isolation and depression, education, job training, housing, dating, pregnancy and child care, workers' rights, and issues and local resources about living life in Changzhou. The Guide was originally modelled on a Chinese Wellness Guide developed in a highly participatory, transdisciplinary project led by HRA (Neuhauser et al. 2013) and now adapted for use in Changzhou. This adaptation illustrates the transdisciplinary strategy of transferring and "re-creating" interventions within new contexts—rather than copying them. Workers and managers have many uses for the Guide. For example, factories use the Guide to orient new workers to life in Changzhou. The Guide is a key resource at the Wellness Houses that offers workers information about many issues that are new to them. Figure 15.2 shows workers at a factory using the Wellness Guide during a discussion of worker issues. After feedback and refinements, a 2nd edition of the Guide was published, and a 3rd edition of the Guide is being developed and will be available in early 2018. The multiple revisions of the Guide have been created following transdisciplinary principles using a highly iterative, participatory process with input from workers, experts and other stakeholders.

Peer-to-peer training, the 3rd major project intervention, takes place in the factories by having a more experienced worker paired with a new worker beginning at orientation. The more experienced workers are typically paid to orient and be a "buddy" to the new worker and train them in technical factory skills, factory life and how to manage issues associated with living in the city. The Wellness House is frequently used for non-technical training and the Wellness Guide is a key resource for the peer-to-peer training. One factory general manager commented on the difficul-

Fig. 15.2 Changzhou factory workers meet in their Wellness House and use the Wellness Guide to plan discussions with workers

ties of recruiting workers and that the project spaces, resources and participatory strategies have become major enticements for workers to join their factory.

15.5.2 The Participatory Process and Other Project Interventions

As mentioned above, the project is driven by a transdisciplinary, participatory process rather than by its specific interventions. When deep participatory processes among diverse people are established, there are no limits to creativity and solution-finding. Importantly, workers and managers have defined robust, novel strategies to improve participation. For example, one factory instituted a "feedback wall" in which workers can write about issues and ideas for change. In another factory, the general manager now invites workers to lunch and listens to their ideas, and worker union representatives are now taking an active role in the project. Workers and managers are also harnessing technology to improve participation. In one factory, the widely used social media app WeChat is used for worker input. Some factories have even set up their own internal evaluations of the project. Another important participatory method has been to share project issues and progress with stakeholder representatives in a yearly conference hosted by the local government. As the project began to expand, factory workers and managers were proud of their projects and eager to share them with other participating factories and with new factories considering joining the project. The conference includes refresher training about the project model, as well as discussions about project progress, planned expansion and discussion of issues and ideas.

The diversity and ingenuity of interventions generated by participation has been impressive. For example, at several factories, workers living within the factory complained about the poor quality of food. In one such factory, workers were successful in having the outside food service contract cancelled, having the workers design the menus and hiring onsite cooks. That effort then expanded to setting up trainings for workers about nutrition and food safety. In a number of factories, community gardens have been established. Because workers are typically not connected to health services, some factories have created their own clinics and invite health, family planning and social service providers onsite to do exams and health education. A common complaint from migrant workers is that they do not feel like they have a "home" once they come to live in a factory. With worker engagement, factories have transformed their worker dorms, set up the worker-designed Wellness Houses, created many opportunities for socializing (such as karaoke and photography competitions), outdoor trips for sightseeing and recreation and many other changes to create a sense of belonging and wellbeing.

15.5.3 Project Evaluation and Initial Qualitative Findings

A project evaluation is being conducted by Nanjing Youdian University, with input from HRA. In addition to ongoing interviews and observations at factories that have documented the above activities and descriptive early outcomes, the evaluation design includes an intervention-control study to be conducted among workers in intervention factories and control factories. Questions include those in the baseline survey comprising a wide range of health, wellness and life issue knowledge, attitudes and behaviors as well as the use of and satisfaction with project interventions (for intervention factory workers). In addition, a cross-sectional study will be done in all 31 factories that will include: a description of project activities, participatory processes, surveys with a sample of about 50 workers in each factory, and in-depth interviews with factory managers, general managers, with Changzhou health and social service providers and other key stakeholders. Case studies will complement these methods. The decision to evaluate all factories involved in the project and adopt a diversity of evaluation methods adheres to transdisciplinary principles of using mixed methods to gather highly contextual information.

Initial qualitative feedback indicates high satisfaction with the project from workers and stakeholders who cite increased availability of health education, psychological counseling, reduction in unwanted pregnancies and abortions, protection of workers' rights, more opportunities for workers to socialize and promote their personal development and increased motivation and efficiency at work. For example, in one factory, managers reported that at the outset of the project, there were high rates of unplanned pregnancies and abortions among workers, endangering workers' health and factory productivity. Once engaged in the project, workers asked for information and training about sexual and reproductive health. Once those activities were implemented for a year, managers reported that unplanned pregnancies and abortions were negligible.

In transdisciplinary programs, meeting the needs of all stakeholders is important. Interviews and case examples to date are showing high satisfaction not only among workers, but also among factory managers, including general managers who run the factories. There is evidence in case reports from management about the projects' impact on improving recruitment and reducing turnover. For example, when we interviewed the general manager of one factory on the outskirts of Changzhou City, he commented that before joining the project, his factory had not been able to recruit workers for 3 years (they did not want to live so far from the city center), and had experienced an 80% turnover of staff. When the project was implemented and workers created an impressive Wellness House and changed other aspects of the factory setting to meet their needs and 'feel more like home', recruitment doubled and turnover dropped to 20%. The general manager commented that the participatory process was critical to meeting the goal of 'healthy workers and happy life'. The project has been so successful in that factory that every potential new worker is first shown the project spaces and activities—before seeing anything else. Likewise, at the outset of the project, health, family planning and social service workers were very concerned about the lack of worker connection to and trust of services and the resulting high risks of disease, unplanned pregnancy, abortion, and mental health problems. This situation is turning around among project factories, primarily because workers *themselves* are asking for services and designing effective ways to connect with them.

In addition, the project has been effective at generating important and initially unexpected policy changes not only for workers in project factories, but also for the 1.5 million migrant workers in Changzhou. One policy change was the aforementioned agreement to allow workers to have required health exams locally, rather than having to go back to their home towns. Another key change that project workers requested was to have their children be able to attend regular schools, rather than the lower quality "migrant schools." When it became apparent that this was a central issue to recruit and keep workers in Changzhou, policymakers agreed to this change. Another overall important policy change is that, as of 2017, the Changzhou government decided that the project would become a regular budget item, indefinitely. As noted above, the government provides one-time seed funding and factories assume responsibility for additional costs after the start-up phase. The shared cost model helps ensure project sustainability and expansion. Some factories report being so positive about the project spaces and activities, that they are expanding wellness spaces and activities—at their own cost.

15.6 Lessons Learned

Addressing the complexity and magnitude of migrant worker issues in China could only be successful with a highly participatory, transdisciplinary approach with collaborators from many disciplines and societal sectors. From the start, stakeholders—including workers who did not traditionally have a strong voice in changing their work and life circumstances—were attracted to and intensely engaged in collaborative processes. Drawing on multiple transdisciplinary frameworks and methods was essential to the success of the project. Importantly, managers were surprised about, and very appreciative of, workers' practical and creative intervention ideas, such as creating Wellness Houses. The Wellness House concept, the attractive, easy-to-use Wellness Guide, the practical system of pairing new and experienced workers and other actions generated by the participatory approach, are now garnering interest in other areas of China. The Project was also able to catalyze major policy changes such as establishing a social support system for migrant workers in the government's working agenda. The project improved grassroots health/family planning and other services for workers who are now much better connected to services and to their community. The detailed issues raised in the project promoted many innovations to service management and to economic development. Finally, the project approach is now being considered as model for national expansion.

From the outset of the project, national leaders were adamant that it be successful on a large-scale, rather than one more 'one off' research project that ends when initial funding is finished. Several principles were adopted to meet this goal. First, the iterative transdisciplinary approach was approved, given its power to elicit problems, generate solutions and gradually refine actions over time—critical to sustainability and expansion. Second, in keeping with transdisciplinary principles, collaborators worked as partners, rather than having one group (such as researchers, professional providers or government officials) claim unilateral ownership and decision-making. Third, from the beginning, project collaborators considered and tested the shared, long-term funding model described above.

Another principle of transdisciplinary work is to engage in "build and evaluate" loops so that it is clear what is working and what needs to change. In this project, there has been constant evaluation and refinement of components. The baseline quantitative and qualitative data was central to early understanding of problems and priority intervention areas. The qualitative feedback gathered since then via observations, interviews and other forms of feedback has been invaluable to gradually revise the project. In the next phase of the project, quantitative (and other qualitative) data will be gathered to document the significance and magnitude of project outcomes on workers, factories, health and social service providers, and on government functions and goals. In keeping with transdisciplinary guidance and the theory and methods of scientific inquiry, diverse qualitative and quantitative methods are needed to guide project development and assess its impact.

15.7 Conclusion

Longstanding concerns about addressing complex problems catalyzed the strong movement toward collaborative research and action across diverse disciplines and societal sectors—or "transdisciplinarity." In parallel, the transformation of thinking about reality and ways of studying it provided a sound scientific foundation supporting transdisciplinarity. Successful transdisciplinary work requires drawing on theory and methods in a range of relevant scientific paradigms and engaging intense participation of stakeholders. Guidance and methods from the design sciences is especially helpful to iteratively plan and refine complex interventions. It is also novel to many of us in health and social sciences who have been trained on more traditional methods. We note that the transdisciplinary process is very different from the traditional one in which researchers define problems, hypotheses, methods and predict outcomes *before* conducting research—a main reason why such research often fails to yield effective solutions. Increasingly, studies are documenting the effectiveness of transdisciplinary work. The Changzhou Worker Wellness Project is an example of applying transdisciplinary strategies to the seemingly unsolvable problems of supporting Chinese migrant workers. We hope the challenges and successes of this project—and others included in this book—will inspire researchers, practitioners and policymakers to take advantage of the unlimited potential of transdisciplinary work.

Acknowledgments We thank the City of Changzhou, China and government officials at the national and Jiangsu Province levels, the National Health and Family Planning Commission, China Family Planning Association, Changzhou City Health and Family Planning Commission, and other Changzhou City service departments, researchers at Nanjing Youdian University and the Health Research for Action center at the University of California, Berkeley, factory managers, and the thousands of workers and many others who have participated in this project. We also appreciate support from Pathfinder International, the Institute for East Asian Studies at the University of California, Berkeley, the Levi Strauss Foundation, the Asia Foundation and Oxfam.

References

Bammer, G. (2013). *Disciplining Interdisciplinarity: Integration and implementation sciences for researching complex real-world problems*. Canberra: Australian National University Press Available at: http://epress.anu.edu.au/titles/disciplining-interdisciplinarity/pdf-download.

Best, A., Hiatt, R. A., & Norman, C. (2006). *The language and logic of research transfer: Finding common ground* [Report]. Working Group on Translational Research and Knowledge Integration, National Cancer Institute of Canada, Toronto, Canada.

Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues, 8*, 5–21.

Cook, T. (1985). Post positivist critical multiplism. In R. Shotland & M. Mark (Eds.), *Social science and social policy* (pp. 25–62). Beverly Hills: Sage.

Deleuze, G., & Guattari, F. (1980). *A thousand plateaus* (B. Massumi, Trans.). London/New York: Continuum. 2004. Vol. 2 of *Capitalism and Schizophrenia*. 2 vols. 1972–1980. Trans. of *Mille Plateaux*. Paris: Les Editions de Minuit.

Dilthey, W. (1998). *Introduction to the human sciences*. Detroit: Wayne State University Press.

Fryer, K. J., Jiju, A., & Douglas, A. (2007). Critical success factors of continuous improvement in the public sector: A literature review and some key findings (PDF). *Total Quality Management, 19*(5), 497–517.

Fuller, R. B., & McHale, J. (1963). *World design science decade, 1965–1975*. Carbondale: Southern Illinois University Press.

Gibbs, P. T. (2014). *A transdisciplinary study of higher education and professional identity*. New York: Springer.

Gibbs, P. (2018). Philosophical reflection: Coda. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Gibbs, P., Neuhauser, L., & Fam, D. (2018). Introduction. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Hadorn, H. G., Pohl, C., & Bammer, G. (2010). Solving problems through transdisciplinary research. In R. Frodeman, J. Thompson Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 431–452). Oxford: Oxford University Press.

Halfon, N., & Hochstein, M. (2002). Life course health development: An integrated framework for developing health, policy, and research. *Milbank Quarterly, 80*(3), 433–479.

Hoffman-Reim, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Hadorn, G. H., Joye, D., Pohl, C., et al. (2008). Idea for the handbook. In G. H. Hadorn, H. Hoffman-Reim, S. Biber-Klemm, W. Grossenbacher-Mansuy, G. H. Hadorn, D. Joye, C. Pohl, et al. (Eds.), *Handbook of transdisciplinary research* (pp. 3–18). London: Springer.

Jensen, P. S. (2003). Commentary: The next generation is overdue. *Journal of the American Academy of Adolescent Psychiatry, 42*(5), 527–530.

Kahn, R. L., & Prager, D. J. (1994). Interdisciplinary collaborations are a scientific and social imperative. *The Scientist, 17*, 11–12.

Klein, J. T. (2018). Learning and transdisciplinary collaboration: A conceptual vocabulary. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Kuhn, T. S. (1962). *The structure of scientific revolutions* (1st ed.). Chicago: University of Chicago Press.

Lewin, K. (1946). Action research and minority problems. *Journal of Social Issues, 2*(4), 34–46.

Lu, M., & Xia, Y. (2016, September). *Migration in the People's Republic of China* (ADBI Working Paper Series. Number 593). Asian Development Bank Institute.

Lubchenco, J. (1998). Entering the century of the environment: A new social contract for science. *Science, 279*(5350), 491–497.

March, S., & Smith, G. (1995). Design and natural science research on information technology. *Decision Support Systems, 15*(4), 251–266.

Minkler, M., & Wallerstein, N. (2008). *Community based participatory research for health: Process to outcomes* (2nd ed.). San Francisco: Jossey-Bass.

Neuhauser, L. (2018). Practical and scientific foundations of transdisciplinary research and action. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Neuhauser, L., & Kreps, G. L. (2014). Integrating design science theory and methods to improve the development and evaluation of health communication programs. *Journal of Community Health, 19*(12), 1460–1471. https://doi.org/10.1080/10810730.2014.954081.

Neuhauser, L., & Pohl, C. (2014). Integrating transdisciplinary and translational concepts and methods into graduate education. In P. T. Gibbs (Ed.), *A transdisciplinary study of higher education and professional identity*. New York: Springer.

Neuhauser, L., Richardson, D., Mackenzie, S., & Minkler, M. (2007). Advancing transdisciplinary and translational research practice: Issues and models of doctoral education in public health. *Journal of Research Practice, 3*(2), Article M19 Available at: http://jrp.icaap.org/index.php/jrp/article/view/103/97.

Neuhauser, L., Kreps, G. L., & Syme, S. L. (2013). Community participatory design of health communication programs: Methods and case examples from Australia, China, Switzerland and the United States. In D. K. Kim, A. Singhal, & G. L. Kreps (Eds.), *Global health communication strategies in the 21st century: Design, implementation and evaluation*. New York: Peter Lang Publishing.

Nicolescu, B. (2010). Methodology of transdisciplinarity – Levels of reality, logic of the included middle and complexity. *Transdisciplinary Journal of Engineering & Science, 1*(1), 19–38.

Nicolescu, B. (2018). The transdisciplinary evolution of the university condition for sustainable development. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Phelan, J. C., Link, B. G., & Tehranifar, P. (2010). Social conditions as fundamental causes of health inequalities. *Journal of Health and Social Behaviour, 51*(1 suppl), S28–S40.

Pohl, C., & Hadorn, G. H. (2007). *Principles for designing transdisciplinary research* (A. B. Zimmerman, Trans.). Munich: OEKOM.

Prior, J., Cuzac, C., & Capon, A. (2018). The role of pliability and transversality within transdisciplinarity: Opening university research and learning to planetary health. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Reason, P., & Bradbury, H. (2008). *The Sage handbook of action research: Participative inquiry and practice*. London/Thousand Oaks: Sage.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*(2), 155–169.

Ross, K., & Mitchell, C. (2018). Transforming Transdisciplinarity: An expansion of strong transdisciplinarity and its centrality in enabling effective collaboration. In D. Fam, L. Neuhauser, & P. Gibbs (Eds.), *The art of collaborative research and collective learning: Transdisciplinary research, practice and education*. Dordrecht: Springer.

Simon, H. (1996). *The sciences of the artificial* (3rd ed.). Cambridge, MA: MIT Press.

Smedley, B. D., & Syme, S. L. (2000). *Promoting health: Intervention strategies from social and behavioral research, Institute of Medicine*. Washington, DC: National Academies Press.

Stokols, D. (2006). Toward a science of transdisciplinary research. *American Journal of Community Psychology, 38*, 63–77.

Sun, X. M., Zong, Z. H., Shu, X., Mao, J. S., Hong, Y., & Wang, X. (2011, October). *Baseline survey results with 1114 migrant workers in Changzhou City*. Nanjing University of Posts and Telecommunication and Changzhou Family Planning Commission. Report.

Sun, X. M., Shu, X. Y., Zong, Z. H., & Mao, J. S. (2012). *A focus group report of Changzhou Wellness Project*. Nanjing College for Population Program Management.

Tapio, P., & Huutoniemi, K. (Eds.). (2014). *Transdisciplinary sustainability studies: A heuristic approach*. New York: Routledge.

Whitehead, M. (1991). The concepts and principles of equity and health. *Health Promotion International, 6*(3), 217–228.

Wilkinson, R., & Marmot, M. (2003). *The solid facts* (2nd ed.). Geneva: World Health Organization.

Zhang, H. (2010). The Hukou System's constraints on migrant workers' job mobility in Chinese cities. *China Economic Review, 21*, 51–64.

Chapter 16
Creative Partnerships and Cultural Organisations: "Enabling" and "Situating" Arts–Science Collaboration and Collective Learning

Tania Leimbach and Keith Armstrong

16.1 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; residency programmes in science research centres; private and public galleries in the form of new commissioned works; 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 interdisciplinary and transdisciplinary approaches to developing the skills and knowledges to engage seemingly intractable problems of the twenty-first century (Malina et al. 2015). In this emerging form of 'boundary work' (Klein 2010), disciplinary differences are seen as strengths, with each practitioner having

[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).

T. Leimbach (✉)
Institute for Sustainable Futures, University of Technology Sydney, Sydney, NSW, Australia
e-mail: tania.leimbach@uts.edu.au

K. Armstrong
School of Creative Practice, Queensland University Technology, Brisbane, QLD, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_16

something to learn from the others, 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 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 they are now found working in hospital clinics, at dissecting tables, in neuro-imaging laboratories and meteorological centres (Wilson et al. 2014a; 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 routine scientific illustration (Ox and Lowenberg 2013; Wilson 2017). Many scientists have become compelled to expand their methods for producing science by working outside their disciplinary boundaries, and in the process they 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 forms of practice more deeply (Leimbach 2015).

Major funding bodies in the USA, the 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

[2] The shift from interdisciplinarity to transdisciplinarity introduces multiple layers of complexity and the need 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 Research Councils United Kingdom (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.

1996 and 2005, and gave its name to a whole area of activity. Over this period the programme fostered hundreds of new collaborations between artists and scientists and helped remove many barriers to cross-disciplinary collaboration. The funding also catalyzed new types of relationships between arts promoters, arts venues, colleagues and peers, and with public and professional audiences (Glinkowski and Bamford 2009). In the USA, the ArtScience movement championed by the Leonardo publishing group and the International Society for the Arts, Sciences and Technology (ISAST) is similarly important.

The SEAD network (the Network for Science, Engineering, Art, Design) established in 2011 represents a broad cross-section of individuals and institutions interested in transdisciplinary collaborative practice (See: www.xsead.cmu.edu). SEAD focuses on four advocacy areas: culture/economic development, research/creative work, learning/education and collaboration/partnership, and it addresses challenges for teamwork in different academic and professional cultures. The terms “enabling” and “situating” in this chapter’s title reference the 11 “action clusters” in *Steps to an ecology of networked knowledge and innovation: enabling new forms of collaboration among sciences, engineering, arts, and design* (Malina et al. 2015). This document draws together findings from dozens of international White Papers examining the feasibility of transdisciplinary collaboration. The authors suggest that taking 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]

16.2 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 et al. 2015) and in the broader literature, notably for sustaining balanced relationships in hybrid practices, and the creative environments that foster and support transdisciplinary practices, backgrounded by our own case-based research.

[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.

16.2.1 Enabling Collaborative Arts–Science Practice: Challenges and Opportunities

There are points of conflict common to many interdisciplinary and transdisciplinary practices. The literature details obstacles resulting from sociological *asymmetries* such as differing personal and institutional environments, incompatible expectations due to dissimilar organizational and commercial pressures, and conflicting funding arrangements (Kemp 2005; Hawkins and Wilson 2014; Malina et al. 2015).[5] Promotion and tenure in universities may also increase resistance to new forms of practice, as do the different economic realities faced by individuals from different professional backgrounds. SEAD also report many more artist-in-residence programmes in science institutions than scientist-in-residence programmes in arts, design and humanities programmes (Malina et al. 2015).

Long-standing assumptions also need acknowledgement to enable productive outcomes. For example, this will involve examining notions of truth and knowledge creation, and resolving the question of whether there can be compatible forms of these across widely divergent areas of human experience and endeavour (Wilson et al. 2014b). 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 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 2014, 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).

16.2.2 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 spaces for collaboration and for diverse publics to be exposed to arts–science projects if

[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).

they can shift or expand their mandates. 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.

16.3 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 artists 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 programme at Bundanon Trust (a rural public arts organization on the South Coast of 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, specializing 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 Ecosophy (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.

16.3.1 The Context: SiteWorks (Bundanon Trust)

Bundanon Trust is a multi-stranded arts organization facilitating the 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 to stay in residence, and to respond to the site through the lens of their specific discipline and through interdisciplinary and transdisciplinary collaborations. Artworks and performances, creative laboratories and collaborations emerge between scientists, artists, local residents and other disciplinary specialists onsite (Ely 2013). 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 on particular themes, such as the future of food, biodiversity and astronomy. The strategies that inform SiteWorks reflect the internal logic of a cultural organization 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).

16.3.2 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'. Armstrong was invited to participate and he proposed a new work, *Black nectar,* arising from ongoing collaborations between

---

[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/).

[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.

Fig. 16.1 *Black nectar,* LED and fibre optic panorama, Bundanon SiteWorks, 2014. (Image: Sam James, Courtesy of Bundanon Trust)

himself and Dr. Peggy Eby (an Australian behavioural ecologist specializing in flying fox research), with key contributions from sound artist Laurence English, ecological scientists Heidi Millington and Luke Lickfold. The final work became a site-specific light and 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. 16.1).

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 programme (Eby and Lunney 2002). By plotting the data across the seasons, Eby is able to understand how flowering events in different 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 amphi-

Fig. 16.2 *Black nectar,* fibre optic lit form, Bundanon SiteWorks, 2014. (Image: Heidrun Lohr, Courtesy of Bundanon Trust)

theatre/forest clearing onsite favoured by Eby for its rich vegetation. Reflecting on the potential of the project to engage audiences, Eby commented (Fig. 16.2):

> 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).

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.

16.3.3 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 on and benefits society, industry and the environment. There are no formal processes in place to assist the gallery in the building of collaborative creative interdisciplinary or transdisciplinary partnerships and research networks across faculty, so the process they use is organic and informal, and it relies upon gallery and academic staff to broker connections. Whilst there are also no formal expectations for gallery staff to engage with other faculties, the gallery needs to reach their internal audience (both staff and students), and so engagement opportunities are actively pursued by gallery staff (UTS Art Interviews).

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

The broader aims of the O|M|H programme were: to trial innovative approaches to understanding science and social contexts, to develop conversations across disciplinary divides, and to 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, and gallery staff sought invitations across the university. 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. 16.3).

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

Fig. 16.3 Keith Armstrong, *Over many horizons,* UTS Art, Sydney, 2016. (Image: Denis Beaubois)

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. 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, for example: *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, and it challenged 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 development 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 offers profound new understandings of humanity based upon ecological frameworks (Fig. 16.4).[8]

[8] Timothy Morton's book *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.

Fig. 16.4 *Over many horizons*, UTS Art, Sydney, 2016. (Image: David Lawrey, courtesy of UTS Art)

Such public dialogue between ‘experts’ and ‘non-experts’ 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).

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.

16.4 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 next section, we present reflections drawn from both sites—a public arts organization 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.

16.4.1 A Public Arts Organization: Supporting Collaboration and Collective Learning

Bundanon Trust encourages experimentation and transdisciplinary collaboration within the structured annual programme 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).

16.4.2 A University Art Gallery: Supporting Collaboration and Collective Learning

UTS Art were supporters of O|M|H's collaborative process. O|M|H successfully fostered partnerships between the university as a research institution, UTS Art as a cultural organization 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 limited by financial and infrastructural constraints. Taking a more process-oriented approach suggests that the use of 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. Collaboration may be hindered by sociological asymmetries including asymmetries in funding, differing demands on teacher-researchers and arts practitioners, and work practices across different disciplines. The development of an appropriate, formalized 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 interdisciplinary 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).

16.5 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 asym-

metry 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.

16.6 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 et al. 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 interdisciplinary 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 include: technical input from on-hand experts 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 processes and a space with a 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 theory and social change theory is valuable, along with clear methods for outreach and education beyond the walls (or gates) of an organization.

Arts–science transdisciplinary partnerships and the collaborative research that underpins them are dynamic and generative and open up scope for collective learning. 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 emphasizes interpersonal exchange, large-scale collaboration and social engagement. The challenges and opportunities are many, both in the creative process and in the surrounding dialogue and debate that is generated when time and space are made available.

References

Aldworth, S., & Ingham, K. (2014). Between: Intersections in art and science in the practice of two contemporary artists. In B. Wilson, B. Hawkins, & S. Sim (Eds.), *Art, science and cultural understanding*. Champaign: Common Ground Publishing.

Bennett, J. (2012). *Living in the Anthropocene* (100 notes, 100 thoughts: Documenta series 053). Ostfildern: Hatje Cantz.

Eby, P., & Lunney, D. (Eds.). (2002). *Managing the Grey-headed flying-fox Pteropus Poliocephalus as a threatened species in NSW: Adjusting to a long-term vision*. Royal Zoological Society of New South Wales Press. http://publications.rzsnsw.org.au/doi/pdf/10.7882/FS.2002.028. Accessed 16 Oct 2016.

Ellsworth, E. (2005). *Places of learning: Media, architecture, pedagogy*. New York/London: Routledge Falmer.

Ely, D. (2013). *Siteworks: A field guide to Bundanon*. North Nowra: Bundanon Trust.

Gabrys, J., & Yusoff, K. (2012). Arts, sciences and climate change: Practices and politics at the threshold. *Science as Culture, 21*, 1–24.

Gibbs, L. (2014). Arts-science collaboration, embodied research methods, and the politics of belonging: ‘Siteworks’ and the Shoalhaven River, Australia. *Cultural Geographies, 21*(2), 207–227.

Glinkowski, P., & Bamford, A. (2009). *Insight and exchange: An evaluation of the Wellcome Trust’s Sciart programme*. Wellcome Trust. http://wellcome.ac.uk/sciartevaluation. Accessed 1 May 2017.

Hawkins, B. (2014). Conversations with artscience practitioners. In B. Wilson, B. Hawkins, & S. Sim (Eds.), *Art, science and cultural understanding*. Champaign: Common Ground Publishing.

Hawkins, B., & Wilson, B. (2014). Transdisciplinary futures and institutional challenges. In B. Wilson, B. Hawkins, & S. Sim (Eds.), *Art, science and cultural understanding*. Champaign: Common Ground Publishing.

Head, L. (2011). More than human, more than nature: Plunging into the river. *Griffith Review, 31*, 37–43.

Kemp, M. (2005). From science in art to the art of science. *Nature, 434*, 308–309.

Klein, J. T. (2010). *Creating interdisciplinary campus cultures: A model for strength and sustainability*. San Francisco: Wiley.

Leimbach, T. (2015). *Sustainability and the material imagination in Australian cultural organisations.* PhD thesis, University of Technology Sydney, NSW.

Malina, R., Strohecker, C., & LaFayette, C. (2015). *Steps to an ecology of networked knowledge and innovation enabling new forms of collaboration among sciences, engineering, arts, and* *design* (On behalf of SEAD network contributors). The MIT Press. http://www.mitpressjournals.org/page/NSF_SEAD. Accessed 20 Mar 2017.

Ox, J., & Lowenberg, R. (2013). What is the challenge of art/science today and how do we address it? *Leonardo, 46*(1), 2.

Root-Bernstein, R., Siler, T., Brown, A., & Snelson, K. (2011). ArtScience: Integrative collaboration to create a sustainable future. *Leonardo, 44*(3), 192.

Rothermel, B. (2012). *The university art museum and interdisciplinary faculty collaboration*. PhD thesis, University of Leicester, UK.

Subramaniam, R. (2013). Art, environment, action. *Women's Studies Quarterly, 41*(3), 265–274.

Wilson, B. (2014). Science and sensibility. In B. Wilson, B. Hawkins, & S. Sim (Eds.), *Art, science and cultural understanding*. Champaign: Common Ground Publishing.

Wilson, B. (2017). ArtScience and the metaphors of embodied realism. In P. Gibbs (Ed.), *Transdisciplinary higher education: A theoretical basis revealed in practice*. London: Springer.

Wilson, B., Hawkins, B., & Sim, S. (Eds.). (2014a). *Art, science and cultural understanding*. Champaign: Common Ground Publishing.

Wilson, B., Sim, S., Hawkins, B., & Biggs, I. (2014b). Voices off. In B. Wilson, B. Hawkins, & S. Sim (Eds.), *Art, science and cultural understanding*. Champaign: Common Ground Publishing.

Chapter 17
Climate Adapted People Shelters: A Transdisciplinary Reimagining of Public Infrastructure Through Open, Design-Led Innovation

Brent Jacobs, Jochen Schweitzer, Lee Wallace, Suzanne Dunford, and Sarah Barns

17.1 Introduction

Contemporary approaches to planning of services and infrastructure for urban communities call for practices that embed stakeholder knowledge to ensure urban resilience and sustainability (Eakin et al. 2017; Reddel and Woolcock 2004). Accordingly, governments have begun to embrace the concepts of co-design and co-production as central tenets of a new paradigm of citizen engagement (McKinlay 2013). This type of deep engagement has so far primarily been employed in larger-scale urban developments (e.g. precinct-scale renewal, city-wide energy or transport systems) (Glackin and Dionisio 2016) because they fundamentally alter urban environments and city liveability (Calhoun 2016; Newton 2012; Thomson and Newman 2016). The contribution of community interactions with small-scale infrastructure to the success of major urban systems is often overlooked, but is critical to place-making and enhanced liveability (Adhitya and Tyler 2016). At this scale, a transdisciplinary (TD) approach and involvement of the users of infrastructure in its design are desirable to ensure the infrastructure meets community needs (Manzini and Rizzo 2011).

B. Jacobs (✉)
Institute for Sustainable Futures, University of Technology Sydney,
Broadway, NSW, Australia
e-mail: Brent.jacobs@uts.edu.au

J. Schweitzer · L. Wallace
Centre for Business and Social Innovation, University of Technology Sydney,
Broadway, NSW, Australia

S. Dunford
NSW Office of Environment and Heritage, Sydney, NSW, Australia

S. Barns
Institute for Culture and Society, Western Sydney University, Parramatta, NSW, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_17

17.1.1 Bus Shelters: Small-scale Infrastructure Supporting Urban Transport Systems

Bus shelters are an example of small-scale infrastructure that supports the functioning of an urban transport system. Inadequate or poorly designed bus shelters present a significant barrier to public transport use that has a disproportionate impact on disadvantaged groups in the community (Hine and Mitchell 2001). In Sydney, Australia, public bus shelters are seldom designed with shelter in mind; their location and construction is predicated on a business model that focuses on visibility for the placement of advertising, and safety concerns and the operational needs of bus services rather than passenger comfort (Fig. 17.1). This has been observed in other cities around the world (e.g. Law and Taylor 2001 for Los Angeles, USA; Lin et al. 2006 for Taiwan). The users of bus shelters, including the elderly, school children and the urban poor, are increasingly exposed to a range of environmental hazards including urban heat (Jacobs and Delaney 2015) and poor air quality (Moore et al. 2018). This highlights the need for more integrated and smart city transport options and innovative designs that better meet the needs of users.

Many cities are also rethinking the design of bus shelters in an era of distributed technologies and smart cities. The integration of smart technologies into bus shelters has fostered relatively simple interventions, such as the inclusion of interactive screens to support trip planning, and the provision of Wi-Fi services and charging stations. More future-focused accounts also highlight the need to rethink the roles and functions of the bus shelter in an era of connected devices and ambient intelligence.

While the majority of technology interventions for bus shelters have focused on the provision of city information services, it is clear that bus shelters have the potential to host data sensing platforms to capture localized data, from passenger traffic flows to temperatures and air pollutants. In this sense, new thinking about the role of smart technologies in bus shelter design should be linked to wider interest in the role of smart cities in addressing current environmental and urban challenges (see Barns 2017; Adler 2015; Batty 2013; Goldsmith and Crawford 2014).

17.1.2 Reimagining Bus Shelters Through Transdisciplinary Research

While the need for greater levels of engagement around bus shelter design is clear, there is a range of competing perspectives on their fundamental attributes that confound innovation (Smart et al. 2009) and which arise because of the roles and responsibilities of the large number of stakeholders involved in decision-making about bus shelters.

Bus shelters in Sydney are possibly the only component of transport infrastructure that is not under the direct management of the transport provider. Instead, local

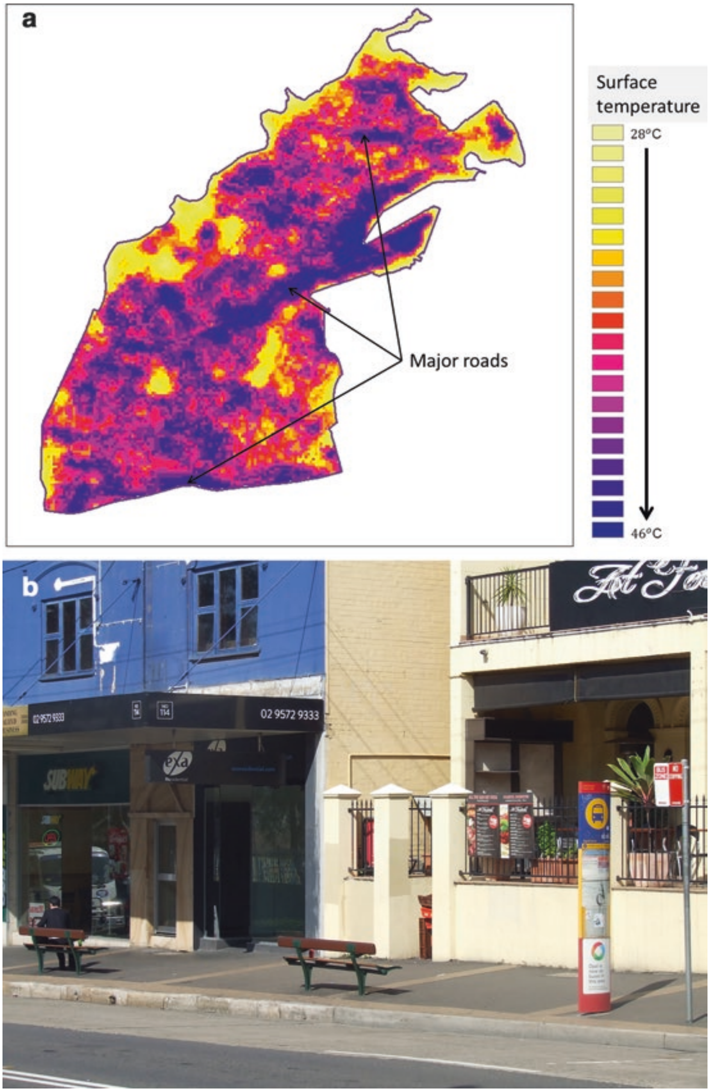

Fig. 17.1 (**a** and **b**) Map of urban heat islands in a typical Sydney suburb showing their co-location with major roads (left) and an exposed suburban bus stop (right)

governments provide bus shelters as part of their management of the streetscape. However, bus shelters are generally included in the streetscape as an afterthought, and they are installed at sites selected to reduce the disruption to traffic flow and enhance bus service operations. In many instances they are fitted into the space remaining after building setbacks, pedestrian footpaths and underground services (water, electricity and telecommunications) have been accommodated. In addition, for major transport routes, the streetscape is controlled by the NSW State

Government transport agency (Roads and Maritime Services in Sydney) further restricting local government's ability to cater for the needs of local residents. Highly technical issues related to transport infrastructure are typically the province of discipline-based experts such as engineers, with often limited experience in community engagement practices. The situation is further complicated by budget restrictions within local government, which are typically 'solved' by outsourcing the construction and maintenance of bus shelters to commercial service providers (Harland et al. 2005). Outsourcing tends to homogenize the service, despite the need to adapt bus shelter design to the local environment (surrounding buildings, available space, aspect etc.), and it means that decisions about the placement of shelters are often based on a desire to maximize advertising revenue.

Transdisciplinary (TD) research is an approach to solving real world problems that: are complex, wicked and multidimensional; feature methodologies that are unbounded by a particular discipline; and are shared and evolve with problem understanding. They are situations in which new knowledge is co-produced with stakeholders (Wickson et al. 2006). As such TD offers a method that integrates stakeholder perspectives, encourages deep reflection on the nature of the problem, and stimulates innovation by revealing the presence of paradoxes that stem from reductionist approaches to problem solving.

17.1.3 Urban Heat As a Driver of Innovation

Over the past 100 years, heat waves have caused more deaths in Australia than any other natural hazard (Steffen et al. 2014). By 2030, Western Sydney is projected to experience up to seven additional days above 35 °C per year, placing exposed communities at heightened risk (AdaptNSW 2015). These communities include Sydney's bus users (currently estimated at approximately 290 million trips per year). Guidance material (NSW Government 2016) advises that bus shelters should provide a comfortable, convenient, reliable, and safe service that is accessible to all. In addition, bus shelter designers are advised to keep in mind the requirements of the elderly; people whose mobility, vision or hearing is impaired; and people with young children, strollers and prams. These groups are often the ones that are most heavily dependent on public transport and they are among the most vulnerable to the effects of urban heat.

Sydney, in common with other rapidly growing global cities, is undergoing both extensive expansion of its urban footprint and significant urban renewal (Crommelin et al. 2017), which provides opportunities for improvements in liveability. The need to adapt to climate change, in particular increasing urban heat, provides an additional driver for improvements to urban infrastructure because design, technological development and societal behaviour interact to alter vulnerability to climate-induced hazards in urban areas (Hunt et al. 2017). The incorporation of adaptation measures in bus shelters would likely have substantial co-benefits for human health and sustainability (Spencer et al. 2017). However, too often disciplinary silos impede knowledge co-production and sharing among the range of actors responsible for the development of infrastructure solutions that are safe, effective, and affordable for transport users and service providers (Russell et al. 2008).

The remainder of this chapter describes the background to and application of an open innovation design-led process as a vehicle for TD research, purposely devised to integrate the diverse forms of knowledge required to reimagine bus shelters as Climate Adapted People Shelters (CAPS). Rather than be bounded by the current institutional conception of bus shelters, our process was focused primarily on understanding and incorporating the current and future needs of the users of street shelters in the context of a changing climate for Sydney. We will conclude with a brief discussion of the difficulties inherent in attempting to mainstream such an approach into the provision of small-scale public infrastructure in urban environments.

17.2 Open Innovation, Design Thinking and Crowd-Sharing

The processes and practices used to achieve innovation outcomes in public infrastructure design in the past have been characterized by a closed innovation paradigm, in which the process leading to innovation is controlled so that, for example, research, ideas and intellectual property are developed internally and kept within an organization's boundary until a new design is released and subjected to feedback from the public. Such processes and practices often fail to take specific locations or user needs in to account.

Recently, open innovation (OI) has become a significant way for organisations to leverage external sources of innovation (Chesbrough 2003; Chesbrough and Bogers 2014; West et al. 2014). New avenues for OI involve engaging with groups of users, consumers and experts as co-creators of knowledge and innovation (Bogers et al. 2010; Piller and West 2014; Von Hippel 2005). To date, the majority of OI studies have taken an organization-centred approach to study knowledge inflows (West and Bogers 2014), commonly drawing upon knowledge theories such as absorptive capacity (Cohen and Levinthal 1990), exploration and exploitation (March 1991; Rivette and Kline 2000) and the knowledge-based view (Kogut and Zander 1996), and directing attention to how external knowledge can be integrated to boost the organization's internal innovation outcomes (Piller and West 2014; Randhawa et al. 2016; Vanhaverbeke et al. 2014).

Experts and users are independent and outside organisations (Lee and Cole 2003; O'Mahony and Bechky 2008) so that OI occurs through an 'interactive coupled model' (Piller and West 2014; West and Bogers 2014). This more complex collaboration involves iterative knowledge exchanges between organisations and members of external groups (Chesbrough and Bogers 2014). Extant OI research provides little insight into how knowledge collaboration occurs between involved parties (Dahlander et al. 2009), and even less insight into how OI intermediaries facilitate such partnerships.

Reviews of the role of intermediaries have focused on innovation contests (Boudreau et al. 2011; Terwiesch and Xu 2008), and tournament-based crowdsourcing (Afuah and Tucci 2012; Lüttgens et al. 2014), where intermediaries broadcast their client organizations' R&D problems to a group of independent individuals (solvers) and offer awards. Much less is known about intermediaries, described as "virtual knowledge brokers" (Verona et al. 2006) and "customer community operators" (Prandelli et al. 2008), that go beyond transactional posting of innovation challenges to more involved curation and management of such collaboration between organisations and user and expert groups (Lüttgens et al. 2014).

Design-led innovation, and particularly design thinking (DT), has been described as a tool for innovation (Martin 2009; Martin 2010) that is applied to break through 'wicked' problems (Buchanan 1992; Camillus 2008), that uncovers an organization's innovation potential for business strategy, and is human-centred, thereby offering new approaches to customer engagement and the development of new products and services. DT is used to describe the ways in which designers approach complex problems and the principles they apply to manage the uncertainties they involve (Brown 2009). The early widespread description of DT (Rowe 1987) has been followed by more recent contributions that further develop its conceptual and practical qualities (Schweitzer et al. 2016). Applying the iterative stages of a typical design-thinking process includes deep empathy with end-users, re-framing the problem area, ideation, prototyping and testing. DT can be seen as a critical practice (Messner et al. 2008) for fostering innovation, particularly through collaborative processes of learning and knowledge creation (Starkey and Tempest 2009; Dunne and Martin 2006).

There has also been a shift away from a focus on rational logic and analysis of innovation opportunities in which the individual is considered key in capitalizing upon opportunities, towards a focus on the processes of innovation embedded within a network base (Parkhe et al. 2006; Jack 2010). Jack (2010), in particular, proposes that a combination of structure and the relational ties between many individuals within networks provides the deepest insights for innovation. Being deeply embedded in broader networks enables people to imagine and empathize with ambiguous future user needs, and this fosters the development of novel solutions, products and services (Chiles et al. 2010). In this way, innovation via DT opens up access to the inputs needed for solving a problem.

Combining OI and DT, we therefore consider 'crowd-sharing' (Schweitzer and Jakovich 2012, 2015) as an approach to create innovation outcomes. A crucial factor to the success of such a combined approach is the inherent openness of design as a practice, whereby creativity emerges from transdisciplinary and interpersonal relations within and between stakeholders. 'Crowd-sharing' emphasizes the relational impact of design thinking to enable innovation through a greater number and greater diversity of participatory interactions surrounding a challenge. Through engagement with external experts and users, organisations can leverage knowledge more fluidly and get to innovative outcomes more quickly. Underlying the idea of 'crowd-sharing' is the proliferation of collaborative tools that have driven new conceptualizations of ownership, participation and commerce. Across diverse domains, an ethos of sharing, cooperation and peer-to-peer exchange is driving new forms of resource distribution and service provision. Many successful examples of (mostly online) cooperation have enabled large groups of people to focus upon specific challenges.

The concept of community design has promoted the acquisition of skills that can be used to develop solutions in a face-to-face environment. Community design utilizes existing concepts of stakeholder consultation that involve motivating local people to develop an active and sustainable 'community' whose members are personally committed to creating a public amenity that satisfies the needs of the community committed to the broader outcome of a public space (Kuznetsov and Paulos 2010). The goal of community design is to embed need-finding into the design process for future users, and to nurture a seed group of passionate community builders. It is this group that will ensure the future success of development strategies, and it is of great interest to the development of a contemporary hybrid—or crowd-sharing. Such community-driven commitment can encourage the adoption of innovation. A 'social incubation' approach can help create a core group that has an influence that is out of proportion to its size Such incubators may consider all participants as agents in an urban system that is enhanced by social networks, sharing and public visualization. A social incubator for innovation has the capacity to positively influence the social, economic, organizational and cultural transformation of the urban fabric through integrated public participation (Foth 2009).

Building on previous studies that have taken a similar conceptual perspective (Boni et al. 2009; Ungaretti et al. 2009; Magadley and Birdi 2009), we provide new insights into the emergence of innovation as a relational process. Whereas previous studies focus on a problem within a specific business, we set the problem context outside of a singular organizational context, and instead we include complex and networked social issues as well as a diverse set of participating stakeholders. The research objective for this project is to better understand how the OI processes and practices commonly employed by intermediaries can facilitate knowledge exchange between public infrastructure planning bodies and groups of external experts and users. In these aspects, DT is consistent with TD approaches to problem solving.

17.3 The CAPS Project

CAPS was a collaboration between the University of Technology Sydney's (UTS's) Institute for Sustainable Futures, ULab and the Centre for Management and Organisation Studies, the NSW Climate Adaptation Research Hub, and the Institute for Culture and Society at Western Sydney University (WSU). UTS received state government funding for CAPS to address climate change risks and vulnerabilities in New South Wales' local governments (or councils). The objectives of the funding stream, the *Building Resilience to Climate Change Contestable Grants Scheme*, included:

- Enhanced consideration of climate change impacts in local and regional decision-making.
- Delivery of projects that minimize climate change impacts for local and regional decision makers
- The fostering of adaptive capacity in local government through a community of practitioners across professional disciplines with direct experience in implementing adaptation responses across NSW.

Local government operations are typically multidisciplinary, and they are organized into functional area teams to manage engineering, town planning, finance, and community services that address place-based geographical, environmental, economic and social circumstances. The multidisciplinary nature of local government (OECD 1998) when coupled with the impacts of climate change at the local scale as a driver of adaptation, makes councils fertile ground for exploring transdisciplinary outcomes and ideal partners for the CAPS project.

CAPS was planned as an open innovation design competition that used methods of human-centred design, and involved the participation of multiple stakeholders and users as well as research to verify the effectiveness of outcomes. The project was envisioned as a 15-month collaboration that involved transport users, local councils, planning and transport authorities, commercial users, and other interested parties at three to five high traffic locations in Western Sydney (Table 17.1).

Table 17.1 Description of the activities included in each stage of the CAPS project and their anticipated timing

Stage	Description	Timing
CAPS plan	Project planning and preliminary stakeholder engagement with project partners. Media planning and engagement. Design and competition brief and production of web and other content.	July–October 2015
CAPS launch	Workshop/event for participating design teams to clarify design and competition criteria and a facilitated session with users and other stakeholders to share stories, experiences and needs. Preliminary research detailing user needs and experiences presented.	November 2015
CAPS ideas	Open workshop where design teams present their concept ideas based on learnings from user research and collect feedback from users, experts and other stakeholders.	February 2016
CAPS prototypes	Public workshop and presentation of prototypes, anticipated user experience and models where further feedback is sought from users, experts and other stakeholders.	April 2016
CAPS reveal and display	Public event where each team presents its final solution design as a model and a panel judged concepts and models according to design criteria. Announcement of competition winners and display of submissions.	June 2016
CAPS build	Winning design built to scale and installed at location in consultation with council.	September 2016
CAPS measure	New shelter effectiveness assessed and documented to inform future urban planning and climate adaptation strategies.	October–December 2016

The competition was framed by a series of open innovation workshops and events to allow project partners, participants and the local community to connect and jointly reveal user needs and design opportunities. Participating design teams developed their ideas with community feedback throughout the competition. The team with the best design was rewarded with the publicity and promotion of their expertise in developing solutions to climate change problems and the opportunity to see their solutions built.

The proposed project timeline aimed at launching the competition before summer 2015 to allow for authentic user-centric data collection, with further feedback workshops and pitch events throughout the process. The winning design was to be built and installed for summer 2016. Table 17.1 contains a rough timetable and a description of each stage of the process.

17.3.1 Competition Brief

At the completion of the CAPS Plan stage, the project partners had engaged four Western Sydney councils in the project: Penrith City (the lead council), Parramatta City, Ashfield and Canterbury City Councils. The development of the competition criteria and the brief to design teams were informed by four design thinking workshops, co-facilitated by trained council community engagement staff, with up to 20 local bus shelter users (Fig. 17.2). Each council invited bus shelter users on their community engagement panels to participate in the workshops, and aimed to include representatives of disadvantaged groups (such as the vision impaired and the elderly) (NSW Government 2013).

The competition was open to anyone over the age of 18 and sought to encourage the participation of multidisciplinary teams made up of designers, architects, landscape architects, engineers, urban planners, inventors, and students. Collaborative teamwork was also encouraged. Teams were expected to participate in and contribute to each stage of the competition. A complete CAPS submission included the following: (1) a user-research report, (2) design documentation, (3) a model/prototype, (4) a 30-second video pitch to be presented online for a CAPS people's choice award, (5) a five-minute video pitch including key features of the concept design (e.g. thermal performance, material choices, cost estimates, desirability, other judging criteria etc.). Finalists were also expected to present their solution in front of the judging panel in June 2016.

17.3.2 Judging Criteria

The original idea was to re-design bus shelters to make them cooler on very hot days. However, user engagement in the CAPS Plan stage indicated that community expectations about the role and performance of bus shelters went far beyond

Fig. 17.2 (**a** and **b**) Preliminary design thinking workshops were conducted with local bus shelter users and employed techniques such as synthetic personas to elicit community perspectives on current service provision

adaptation to climate (Table 17.2). The need for design solutions that were unique and contextual rather than 'one-size fits all' became obvious to the research team. Accordingly, the criteria devised to select a competition winner were scoped by the research team to include designs that were:

Desirable: Evidence of a user-centric approach to identify and address key user needs and location specific aspects via insights from in-depth engagement with

Table 17.2 A series of insights from bus shelter users elicited through the four CAPS Plan workshops that informed the broadening of the competition judging criteria

(a) Many users of public transport report a seamless public transport experience elsewhere in the world and can't understand why it doesn't happen in Sydney.
(b) Transport users require a system that supports the vulnerable (very young, old, disabled and or unwell) who are impacted by urban heat.
(c) Some very simple improvements could create a much more comfortable waiting experience.
(d) Real-time bus information is required since not everyone has a smart phone.
(e) More trees would make a big difference. People like trees.
(f) Advertising or solid walls or panels block visibility and less mobile users may miss their transport.
(g) In some areas waiting times are very long in off-peak periods.
(h) Comfort is important. Users define comfort as cool in summer and warm and dry and out of the wind in winter.
(i) It would be a good idea to enable passengers to recharge transport smart cards nearby
(j) Prams, wheelchairs, luggage and shopping should fit into the shelter.
(k) Users like the bus shelters to be well maintained and they like the surrounding area to be tastfully landscaped
(l) Clear signage in larger letters would help the elderly
(m) Some light so people can read while waiting.
(n) Some users would like the shelters to be used to display works of art
(o) Sound/light signal for approaching bus would help the visually impaired and deaf.

local users achieved through interviews conducted during site visits. Specific user needs could include elderly seeking comfort, disabled seeking access, teenagers seeking connectivity, families seeking visibility or busy people seeking easy transfer options etc. General important aspects could include provision of ventilation, shade, information display, protection from the elements, visibility of approaching traffic and safety.

Smart: The proposed solution should integrate digital technologies to support the functional performance of the shelter. Digital tools or sensors could be used to allow improved responsiveness of the shelter to environmental conditions or user needs, or as communication platforms for the delivery of information services to users. Opt-in services could be considered that allow shelters to act as data collection points for wider integration to support transport improvements and adaption measures. SMART features could relate, for example, how the shelter generates its own energy, displays latent capacity from transport services, forecasts demand or travel time, or adjusts itself to changing weather conditions.

Adapted: The shelter design should respond to the challenges of climate change as they relate to people shelters. This could be achieved through choice of materials, orientation, interaction with the surrounding environment, integration with existing structures, etc. To be *adapted* the shelter should provide a comfortable and protected space for its users that responds not only to heat but also other climatic elements. Shelters should also be resilient to climate extremes to minimize ongoing repairs and maintenance and maximize performance over their expected life.

Valuable: The solution must be compliant with the requirements of the Disability Discrimination Act 1992 and must not cost more than AU$15,000 to construct (excluding site surface preparation). Mechanisms to generate revenue (e.g. through advertising) may be incorporated. The design should also consider minimizing any ongoing maintenance requirements which may result in a cost to council.

17.4 Findings and Discussion

Design competitions are increasingly used to stimulate ideas and catalyze innovation in a range of areas. In particular they are used to 'focus entrepreneurial attention on pressing social needs' (Lampel et al. 2012, p. 14). The launch of the CAPS competition elicited registrations from 30 design teams. Teams of professionals drawn from the design and engineering establishments (such as architectural firms) were well represented, with some initial interest from international groups (Hong Kong and New Zealand). Educational institutions also saw opportunities for training students in user-centred design: two teams of undergraduate students and two of students from local high schools also registered. Although some participants withdrew at each stage of the process, ten high-quality entries that met the competition criteria were selected to proceed to judging. These entries covered six of the eight locations offered by the participating councils, each with a distinct combination of site-specific issues addressed.

Lampel et al. (2012) identified three distinct methods of assessment for design competitions: assessment by a jury of experts with specialist knowledge and/or a public profile; peer assessment by the design community of practice; and assessment by public popular acclaim. CAPS was assessed in two ways, which supported the transdisciplinary nature of the project. The overall winner was selected by a panel of judges drawn from a broad range of backgrounds to ensure multiple perspectives were accounted for in the selection of the winning entry. Judges represented local politics (the Mayor of Penrith City), commerce (Samsung), academia (Macquarie University climate change researcher), urban planning (Environment Commissioner of the Greater Sydney Commission), and commercial development (Stockland). In addition, a 'people's choice' winner was selected through an online voting procedure open to the general public to raise awareness and provide an opportunity to 'close the loop' on knowledge co-production within the CAPS process.

17.4.1 Winning Design

The winning design, submitted by a local small business (MM Creative, Fig. 17.3), was selected because it demonstrated a range of innovative features: adaptability, modularity, shade and temperature control incorporated through use of modern

Fig. 17.3 The winning CAPS design submitted by MM Creative

materials and fabrication techniques. In addition, it best met the requirements of the design brief by including:

- 'Biomimicry' in the design of the roof profile, which was inspired by the wings of the whistling kite, a bird native to the local area
- Adjustable seating with rotatable positioning to improve ventilation and visibility, and customizable-interchangeable construction materials
- Adjustable shade and ventilation panels to enhance user protection and allow incorporation of artistic expression in the panel surface
- An optional communications and technology hub with LED information screens, Wi-Fi connectivity, audio speakers, solar charging, surveillance camera and a smart card reader
- Insulated roofing panels
- Options for the inclusion of a low maintenance green wall or planter boxes to utilize rainfall
- Self-adjusting LED lighting
- Disability and safety compliance.

The in-kind contributions of the design teams that entered CAPS were significant. MM Creative estimated the cost of developing their CAPS entry at about $50,000, a considerable impost for a small to medium enterprise. The design community has begun to caution designers about the possibility of exploitation of their intellectual property because of the rapid expansion in the number of innovation competitions and events (Bennett 2013). We sought to eliminate the potential for exploitation by:

- Ensuring all intellectual property was retained by the design teams, as stated under the legal principles governing the conduct of the competition

- Promoting the designs and teams to a broad range of decision-makers in forums outside the competition process
- Directing inquiries about designs or specific innovation features to the design teams for follow up.

17.4.2 Smart Technologies

While the design concepts submitted did not fully utilize the range of smart technologies available for integration into future bus shelter design, a precedent review conducted to support the project provided the opportunity to reflect on the future relationships between people shelters, urban heat and distributed technologies. This research recognized that people shelters are a useful ‘everyday infrastructure’ for trialling new smart services, and are particularly useful for the delivery of context-aware information to commuters who may not otherwise access smartphone services. It also found that the use of environmental sensors at bus shelters can also support the capture of more granular environmental data relating to urban heat and its impact on different kinds of urban vulnerability (Barns 2017).

17.5 CAPS As TD Research: Reflections

Transdisciplinarity proved a useful lens through which to view our open innovation approach to the design of small-scale infrastructure. In keeping with the definition of TD offered by Wickson et al. (2006), the CAPS design process concentrated on identifying solutions to a real world problem: that of improving the climate performance of Sydney’s bus shelters. The problem proved to be complex, wicked and multi-dimensional and required the research team to embrace new ways of problem investigation that transcended the disciplinary silos of climate change projections, infrastructure engineering and transport planning. A feature of the CAPS process was the incorporation of co-design and knowledge co-production with stakeholders, particularly bus shelter users—a group that in the past had been largely ignored in the provision of this infrastructure. The CAPS project directly engaged approximately 350 participants from across local government, design, research, education and community groups. However, the project’s reach extended further through online, local and mainstream media coverage, which we believe demonstrates a desire from communities for greater involvement in collaborative innovation to improve community infrastructure.

Our attempts to move beyond design to fabrication and installation of the wining CAPS entry revealed further barriers to innovation adoption, and lessons generally for adaptation to climate of small-scale infrastructure in urban renewal (Burch et al. 2014). These barriers related to the inflexibility of institutional arrangements to accommodate, in existing governance processes, non-standard designs and slightly unorthodox construction procedures. For example, business models within local government procurement (such as outsourcing of road closures and traffic management during construction) and the connection of services (water, power) to the site became highly problematic. These issues required engagement with council engineers and large utilities, who had little incentive to adapt wide-scale governance processes to user needs and local environmental management. We observed a tendency to try to make the innovation conform to existing governance rather than the reverse.

At the time of writing, the barriers to installation appear to have been overcome and site preparation completed ahead of shelter installation, albeit many months behind schedule. It would be tempting to view these delays as evidence of institutional failure to react adequately to obvious community need. However, our aim in undertaking the CAPS project was to be deliberately disruptive to current accepted practices (Eggers et al. 2012). We believe in this regard we were successful, and that the impediments to innovation we revealed through the CAPS project merely present further opportunities for TD research.

Acknowledgements The project is supported through the Building Resilience to Climate Change grants scheme, funded by the NSW Office of Environment and Heritage and the NSW Environmental Trust and administered by Local Government NSW. We thank the staff of participating Councils, in particular Carmel Hamilton, Sustainability Coordinator, Penrith City, for their assistance with the project. We thank the participating design teams, especially the competition winner MM Creative (http://www.micronmanufacturing.com.au/).

References

Adam Moore, Miguel Figliozzi, Christopher M. Monsere, (2018) Air Quality at Bus Stops. Transportation Research Record: Journal of the Transportation Research Board 2270 (1):76-86

Adhitya, S., & Tyler, N. (2016). Small things with big impact in urban infrastructure design. *International Journal of Complexity in Applied Science and Technology, 1*(1), 61–85.

Adler, L. (2015). *The urban internet of things. Data-smart city solutions*. http://datasmart.ash.harvard.edu/news/article/the-urban-internet-of-things-727. Accessed 18 Sept 2017.

Afuah, A., & Tucci, C. L. (2012). Crowdsourcing as a solution to distant search. *Academy of Management Review, 37*, 355–375.

Barns, S. (2017). *Using smart technologies for climate change adaptation in Western Sydney: A CAPS Research Report*. https://www.uts.edu.au/sites/default/files/CAPS_Research_Final.pdf. Accessed 3 July 2017.

Batty, M. (2013). *The new science of cities*. Cambridge, MA: MIT Press.

Bennett, N. (2013). *Opinion: Why you should stop entering design competitions*. Digital Arts. http://www.digitalartsonline.co.uk/news/creative-business/opinion-why-entering-design-competitions-is-often-really-working-for-free/. Accessed 7 June 2017.

Bogers, M., Afuah, A., & Bastian, B. (2010). Users as innovators: A review, critique, and future research directions. *Journal of Management, 36*(4), 857–875.

Boni, A. A., Weingart, L. R., & Evenson, S. (2009). Innovation in an academic setting: Designing and leading a business through market-focused, interdisciplinary teams. *Academy of Management Learning & Education, 8*(3), 407–417.

Boudreau, K. J., Lacetera, N., & Lakhani, K. R. (2011). Incentives and problem uncertainty in innovation contests: An empirical analysis. *Management Science, 57*(5), 843–863.

Brown, T. (2009). *Change by design*. New York: HarperCollins.

Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues, 8*(2), 5–21.

Burch, S., Shaw, A., Dale, A., & Robinson, J. (2014). Triggering transformative change: A development path approach to climate change response in communities. *Climate Policy, 14*(4), 467–487.

Calhoun, S. (2016). How Melbourne became the most liveable city in the world. *Planning News, 42*(1), 12.

Camillus, J. C. (2008). Strategy as a wicked problem. *Harvard Business Review, 86*(5), 98.

Chesbrough, H. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard: Harvard Business School Press.

Chesbrough, H., & Bogers, M. (2014). *Explicating open innovation: Clarifying an emerging paradigm for understanding innovation*. Oxford: Oxford University Press.

Chiles, T. H., Tuggle, C. S., McMullen, J. S., Bierman, L., & Greening, D. W. (2010). Dynamic creation: Extending the radical Austrian approach to entrepreneurship. *Organization Studies, 31*(1), 7–46.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128–152.

Crommelin, L., Bunker, R., Troy, L., Randolph, B., Easthope, H., & Pinnegar, S. (2017). As compact city planning rolls on, a look back: Lessons from Sydney and Perth. *Australian Planner, 54*(2), 115–125. https://doi.org/10.1080/07293682.2017.1319869.

Dahlander, L., Frederiksen, L., & Rullani, F. (2009). Online communities and open innovation. *Industry and Innovation, 15*(2), 115–123.

Dunne, D., & Martin, R. L. (2006). Design thinking and how it will change management education: An interview and discussion. *Academy of Management Learning & Education, 5*(4), 512–523.

Eakin, H., Bojórquez-Tapia, L. A., Janssen, M. A., Georgescu, M., Manuel-Navarrete, D., Vivoni, E. R., Escalante, A. E., Baeza-Castro, A., Mazari-Hiriart, M., & Lerner, A. M. (2017). Opinion: Urban resilience efforts must consider social and political forces. *Proceedings of the National Academy of Sciences, 114*(2), 186–189.

Eggers, W., Baker, L., Gonzalez, R., & Vaughn, A. (2012). Disruptive innovation: A new model for public sector services. *Strategy & Leadership, 40*(3), 17–24.

Foth, M. (2009). *Handbook of research on urban informatics: The practice and promise of the real-time city*. London: IGI Global.

Gianmario Verona, Emanuela Prandelli, Mohanbir Sawhney, (2006) Innovation and Virtual Environments: Towards Virtual Knowledge Brokers. Organization Studies 27 (6):765-788

Glackin, S., & Dionisio, M. R. (2016). Deep engagement' and urban regeneration: Tea, trust, and the quest for co-design at precinct scale. *Land Use Policy, 52*(2016), 363–373.

Goldsmith, S., & Crawford, S. (2014). *The responsive city: Engaging communities through data-smart governance*. San Francisco: Wiley.

Harland, C., Knight, L., Lamming, R., & Walker, H. (2005). Outsourcing: Assessing the risks and benefits for organisations, sectors and nations. *International Journal of Operations & Production Management, 25*(9), 831–850.

Hine, J., & Mitchell, F. (2001). Better for everyone? Travel experiences and transport exclusion. *Urban Studies, 38*(2), 319–332.

Hunt, J. C. R., Aktas, Y. D., Mahalov, A., Moustaoui, M., Salamanca, F., & Georgescu, M. (2017). *Climate change and growing megacities: Hazards and vulnerability*. In Proceedings of the Institution of Civil Engineers – Engineering sustainability: Engineering sustainability. https://doi.org/10.1680/jensu.16.00068.

Jack, S. L. (2010). Approaches to studying networks: Implications and outcomes. *Journal of Business Venturing, 25*(1), 120–137.

Jacobs, B., & Delaney, C. (2015). *Adapting to heat: Leichhardt Municipal Council*. Prepared for Leichhardt Municipal Council by the Institute for Sustainable Futures, University of Technology Sydney.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organization Science, 75*(5), 502–518.

Kuznetsov, S., & Paulos, E. (2010). Rise of the expert amateur: DIY projects, communities, and cultures. In *Proceedings of the 6th Nordic conference on human-computer interaction: Extending boundaries* (pp. 295–304). New York: ACM.

Lampel, J., Jha, P. P., & Bhalla, A. (2012). Test-driving the future: How design competitions are changing innovation. *The Academy of Management Perspectives, 26*(2), 71–85.

Law, P., & Taylor, B. (2001). Shelter from the storm: Optimizing distribution of bus stop shelters in Los Angeles. *Journal of the Transportation Research Board, 1753*(2001), 79–85.

Lee, G. K., & Cole, R. E. (2003). From a firm-based to a community-based model of knowledge creation: The case of the Linux kernel development. *Organization Science, 14*(6), 633–649.

Lin, T. P., Matzarakis, A., & Huang, J. J. (2006). Thermal comfort and passive design of bus shelters. In *Proceedings of 23rd conference on passive and low energy architecture* (PLEA2006), Geneva.

Linus Dahlander, Lars Frederiksen, Francesco Rullani, (2009) Online Communities and Open Innovation. Industry and Innovation 15 (2):115-123

Lüttgens, D., Pollock, P., Antons, D., & Piller, F. (2014). Wisdom of the crowd and capabilities of a few: Internal success factors of crowdsourcing for innovation. *Journal of Business Economics, 84*(3), 339–374.

Magadley, W., & Birdi, K. (2009). Innovation labs: An examination into the use of physical spaces to enhance organizational creativity. *Creativity and Innovation Management, 18*(4), 315–325.

Manzini, E., & Rizzo, F. (2011). Small projects/large changes: Participatory design as an open participated process. *CoDesign, 7*(3–4), 199–215.

March, J. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2*(1), 71–87.

Martin, L. (2009) The design of business: Why design thinking is the next competitive advantage. Boston: Harvard Business Press.

Martin, R. L. (2010). Design thinking: Achieving insights via the "knowledge funnel". *Strategy & Leadership, 38*(2), 37–41.

McKinlay, P. (2013). Governance and the co-design of services: The importance of a "governance perspective". *Asia Pacific Journal of Public Administration, 35*(1), 53–70.

Messner, M., Clegg, S., & Kornberger, M. (2008). Critical practices in organizations. *Journal of Management Inquiry, 17*(2), 68–82.

Moore, A., Figliozzi, M., & Monsere, C. M. (2018). Air quality at bus stops. *Transportation Research Record: Journal of the Transportation Research Board, 2270*(1), 76–86.

Newton, P. W. (2012). Liveable and sustainable? Socio-technical challenges for twenty-first-century cities. *Journal of Urban Technology, 19*(1), 81–102.

NSW Government. (2013). *Integrated planning and reporting manual for local government in NSW*. The Division of Local Government, Department of Premier and Cabinet, Nowra, NSW, Australia. https://www.olg.nsw.gov.au/sites/default/files/Intergrated-Planning-and-Reporting-Manual-March-2013.pdf. Accessed 18 Sept 2017.

NSW Government. (2016). *Audit Office of NSW*. http://www.audit.nsw.gov.au/publications/latest-reports/financial/volume-nine-2016-transport/introduction. Accessed 29 May 2017.

O'Mahony, S., & Bechky, B. A. (2008). Boundary organizations: Enabling collaboration among unexpected allies. *Administrative Science Quarterly, 53*(3), 422–459.

OECD. (1998). *Interdisciplinarity in science and technology. Directorate for Science, Technology and Industry*. Paris: OECD.

Parkhe, A., Wasserman, S., & Ralston, D. A. (2006). New frontiers in network theory development. *Academy of Management Review, 31*(3), 560–568.

Piller, F., & West, J. (2014). *Firms, users, and innovation. New frontiers in open innovation*. Oxford: Oxford University Press.

Prandelli, E., Swahney, M., & Verona, G. (2008). *Collaborating with customers to innovate: Conceiving and marketing products in the networking age*. Northampton: Edward Elgar.

Randhawa, K., Wilden, R., & Hohberger, J. (2016). A bibliometric review of open innovation: Setting a research agenda. *Journal of Product Innovation Management, 33*(6), 750–772.

Reddel, T., & Woolcock, G. (2004). From consultation to participatory governance? A critical review of citizen engagement strategies in Queensland. *Australian Journal of Public Administration, 63*(3), 75–87.

Rivette, K. G., & Kline, D. (2000). *Rembrandts in the attic: Unlocking the hidden value of patents*. Boston: Harvard Business School Press.

Rowe, P. G. (1987). *Design thinking*. Cambridge, MA: The MIT Press.

Russell, A. W., Wickson, F., & Carew, A. L. (2008). Transdisciplinarity: Context, contradictions and capacity. *Futures, 40*(5), 460–472.

Schweitzer, J., & Jakovich, J. (2012). *Crowd-share innovation – Intensive creative collaborations*. Project Freerange, Melbourne.

Schweitzer, J., & Jakovich, J. (2015). The emerging potential of crowd sharing: Learning and innovation beyond the organizational context. In F. Soliman (Ed.), *From knowledge management to learning organization to innovation: The way ahead!* (pp. 208–231). Cambridge: Cambridge Scholars Publishing.

Schweitzer, J., Groeger, L., & Sobel, L. (2016). The design thinking mindset: An assessment of what we know and what we see in practice. *Journal of Design, Business & Society, 2*(1), 71–94.

Smart, M., Miller, M. A., & Taylor, B. D. (2009). Transit stops and stations: Transit managers' perspectives on evaluating performance. *Journal of Public Transportation, 12*(1), 59–77.

Spencer, B., Lawle, J., Lowe, C., Thompson, L., Hinckley, T., Kim, S. H., Bolton, S., Meschke, S., Olden, J. D., & Voss, J. (2017). Case studies in co-benefits approaches to climate change mitigation and adaptation. *Journal of Environmental Planning and Management, 60*(4), 647–667.

Starkey, K., & Tempest, S. (2009). The winter of our discontent: The design challenge for business schools. *Academy of Management Learning & Education, 8*(4), 576–586.

Steffen, W., Hughes, L., & Perkins, S. (2014). *Heatwaves: Hotter, longer, more often*. Climate Council of Australia. https://www.climatecouncil.org.au/heatwaves-report. Accessed 18 July 2017.

Terwiesch, C., & Xu, Y. (2008). Innovation contests, open innovation, and multiagent problem solving. *Management Science, 54*(9), 1529–1543.

Thomson, G., & Newman, P. (2016). Geoengineering in the Anthropocene through regenerative urbanism. *Geosciences, 6*(4), 46. https://doi.org/10.3390/geosciences6040046.

Ungaretti, T., Chomowicz, P., Canniffe, B. J., Johnson, B., Weiss, E., Dunn, K., & Cropper, C. (2009). Business+ design: Exploring a competitive edge for business thinking. *SAM Advanced Management Journal, 74*(3), 4–11.

Vanhaverbeke, W., Chesbrough, H., & West, J. (2014). *Surfing the new wave of open innovation research. New frontiers in open innovation*. Oxford: Oxford University Press.

Verona, G., Prandelli, E., & Sawhney, M. (2006). Innovation and virtual environments: Towards virtual knowledge brokers. *Organization Studies, 27*(6), 765–788.

Von Hippel, E. (2005). *Democratizing innovation*. Cambridge, MA: MIT Press.

West, J., & Bogers, M. (2014). Leveraging external sources of innovation: A review of research on open innovation. *Journal of Product Innovation Management, 31*(4), 814–831.

West, J., Salter, A., Vanhaverbeke, W., & Chesbrough, H. (2014). Open innovation: The next decade. *Research Policy, 43*(2014), 805–811.

Wickson, F., Carew, A. L., & Russell, A. W. (2006). Transdisciplinary research: Characteristics, quandaries and quality. *Futures, 38*(9), 1046–1059.

Chapter 18
Reflections on Collective Learning: Open and Closed

Valerie A. Brown

18.1 Context for Collective Learning Workshops

> Forget your perfect offering. There is a crack, a crack in everything: that's how the light gets in. Leonard Cohen (1992): *Anthem*

In times of change, members of the changing society are involved in collective learning by default. That we can learn from change is a key characteristic of our species. It allows us to fit into the society in which we were reared. Mary Midgely discusses the ways in which societies shape the thinking of their individual members and the individuals shape their society (Midgley 1990). It follows that a society's capacity to respond to change depends on the willingness of its members to go beyond their traditions of social learning. Helga Nowotny describes the degree of discord between traditionally divided ways of thinking and new moves to open learning. According to Nowotny, times of change require what she calls Mode-2 knowledge, in which the two ways of thinking support each other (Nowotny et al. 2001).

Pressures for change manifest themselves in multiple ways. Financial crises follow one another, with no end in sight (Friedman 2000). Advances in technology appear to offer answers, and the answers cause further disruption. Communities may or may not support their members to cope with the rapid pace of social change. Experts offer competing solutions to the same issues. Organisations have their own solutions. In spite of all this, there is broad agreement that the impact of these activities on the planet is so great that collective learning among all the interest groups is necessary for a viable human future (Brown 2005; Hamilton 2017). Questions that arise include: Do the current moves towards transdisciplinarity include the multiple ways of thinking

V. A. Brown (✉)
Fenner School of Environment and Society, Australian National University, Canberra, ACT, Australia

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_18

needed for whole-of-society change? And; Does whole-of-society change involve individuals' collective thinking to correct that of predetermined groups?

Transdisciplinary inquiries are defined as inquiries which bring academic disciplines together with other ways of thinking, such as those of the community, professions, and organisations. The second chapter in this volume contains a comprehensive thesaurus for a language of transdisciplinary collaboration developed by Julie Thompson Klein (Klein 2018, Chap. 2 in this book). Over time, it has become clear that collective learning for social change is a transformative enterprise, able to bring together different ways of thinking on equal terms, and of embracing the diversity of their contributions (Brown and Lambert 2012).

The accounts of social change projects below provide examples of why individuals' collective learning is crucial to whole-of-society change. In each of the learning cycles in the Local Sustainability Project, collective learning was needed to support the participants in the complex decision-making processes of social change. As confirmed in the first round of workshops, previous work has identified ways in which Western decision-making is carried out by discrete knowledge sub-cultures, each with its own way of operating. The decision-makers include free-thinking individuals, loyal community members, respected experts, organizations agendas, and holistic thinkers. Related analyses can be found in Fleck (1979), Adam et al. (2000), Brown et al. (2010), and Ansell (2011). In collective learning, each individual can call into question fixed ways of thinking.

In the scientific era, it had become usual practice for complex issues to be addressed by one preferred way of thinking. A problem becomes a wicked problem when it proves unsolvable by any of the methods in current use (Rittel and Webber 1973). Typical of the choices to be made include whether a community needs to alter the way it delivers services, or whether it should continue to deliver more of the same. Halting environmental degradation could mean introducing an adaptive management system, or protecting one iconic species. An individual has the task of deciding whether a certain issue requires changes in their own behaviour, or whether they should leave change to their society. If the choice is to make the simpler response, the response can be explored through the Newtonian logic of cause and effect. Once a problem is recognized as a wicked problem, its resolution requires mutual learning among the many interested parties, incorporating their multiple ways of thinking (Brown et al. 2010).

In the community change programmes discussed below, a suitable framework for collective learning would bring together the steps from ideas to action, and encourage rather than impede change. In studies of collective thinking by the Local Sustainability Project (LSP) of the Australian National University, the chosen framework was David Kolb's experiential learning cycle (Kolb 1984; Brown 2008). Other integrating frameworks were based on specialized interests, such as the environmental context (Boyden et al. 1981) and people's health (Hancock 2016). Kolb developed a learning cycle as an open process for change not wedded to specialized inquiries. While Kolb's cycles were originally designed for individual learning, the Local Sustainability Project team adapted the cycle to work with groups in which individuals learn from each other (Brown 2008).

An open learning cycle values contributions from individuals and from groups. The steps follow plain common sense. However, starting with the participants' visions runs counter to the usual presentation of 'the facts' before values. This approach cements discussion in current issues rather than opening up the desired change. The steps in collective learning practice are, first, to share the different aims (*ideals* for what should be), followed by a search for the necessary evidence to support the aims (*facts* to describe what is); then brainstorming practical ways for resolving the issues (*ideas* for what could be); and finally putting the ideas into practice (*actions* testing what can be).

As an example, for Australia's biggest river system, the Murray-Darling, the aim of whole-of-community change was to satisfy the water needs of everyone, from agricultural production and nature conservation to population health. All participants in these projects were asked to share their ideals and contribute their own versions of the facts. The whole group then brainstormed new ideas for achieving their goals. Putting each cycle into action led to fresh learning, which created new visions of the future and started off a fresh cycle. The cycle then becomes a spiral (Aslin and Brown 2004).

18.2 Multiple Ways of Thinking

The Local Sustainability Project team applied the collective learning cycle as partners with over 300 self-chosen transformational change programmes in Australia, Africa, Asia and Europe, between 1995 and 2015. The Project identified groups with distinctive ways of thinking within each learning cycle, including interested groups (often called stakeholders), knowledge sub-cultures and independent individuals. Examples below offer a blueprint for introducing the collective learning cycle to individual learning, small groups and a whole community. Application of the collective learning cycle drew on Michel Piaget's (1951) stages of intellectual development; Paolo Freire's emphasis on the need for learning through conscious reflection (Freire 1996); Kurt Lewin's insights into organizational cultures (1943); Carl Jung's 1964 assertion that learning involves an individual's preferred ways of adapting to the world and John Dewey's commitment to civil society (1910). A powerful foundation for delivering collective learning.

The Local Sustainability Project workshops involved linking residents, community groups, specialists, local councils and businesses, and policy developers, to transformational change in their community. The workshops generated questions on key aspects of collective learning. One: What are the current divisions of knowledge that can support whole-of-community change? Two: What is the role of individuals in social learning for social change?

18.2.1 Publication of Study Findings

First, the study found that the dominant mode of structuring knowledge in the Western cultural tradition was in separate compartments, marked by individual, community, expert, organizational and holistic ways of knowing. Expert and organizational learning were the most influential knowledge sub-cultures (Brown 2008; Brown et al. 2010).

Second, the study found that individuals could break free from those compartments and access their own innovative thinking, which included biophysical, socio-economic, ethical, artistic and sympathetic ways of thinking (Brown and Harris 2014; Brown 2015).

The first round of workshops discovered that the proposed changes were locked into the fixed positions of socially constructed compartments of knowledge. This meant it could be difficult to move forward with fresh ideas. Looking for a way of re-framing the interest groups, the LSP team reviewed the Western Greco-Roman tradition of knowledge cultures, each with its own language, content and skills. Passmore (1970) and Gould (2003) are part of a long tradition of exploring the consequences of expanding compartmentalized knowledge.

The LSP team found that, in practice in their workshops, knowledge was divided into individual, community, expert, organizational and holistic knowledges, each with its own language, aims, type of solution and power base. In the sample case of the Australian Murray-Darling river system, individuals drew on their experience; communities drew on shared events; experts drew on their observations; organisations referred to their own agendas: and holists, drew on a combination of the others. Each way of thinking tended to reject the others. Individuals were described as biased; communities as self-centred; experts as talking jargon; organisations as self-centred, and holistic thinkers as airy-fairy (Aslin and Brown 2004, Nowotny et al. 2001).

On the positive side, Western knowledge sub-cultures have a strong track record for advancing knowledge in all their specialized compartments. Individuals are awarded Nobel prizes for breakthroughs in physics, astronomy and literature. Communities have developed lifestyles that make them the envy of the rest of the world. Experts have expanded the detailed knowledge bases of all disciplines and professions. Organisations have become both powerful and efficient. Holistic thinkers have often provided the breakthroughs that everyone needed. Despite this fragmentation, or perhaps because of it, the scientific era transformed societies. The changes drew on all these compartments of knowledge, while often only acknowledging one: usually scientific or organizational (Gould 2003).

In a second round of workshops, the LSP team built on the finding of Stage 1 that the Western knowledge was divided into closed sub-cultures. The pathway to collected thinking lay in bringing together groups drawn from each of the knowledge compartments. The aim was not to arrive at consensus, but rather to arrive at mutual learning that included all the siloed ways of thinking. Not an easy task, given the extent of the differences, and the strength of the boundaries erected between them.

In practice, the groups each had enough in common with the focus question to enjoy the collective learning exercise (Brown and Lambert 2012).

Nevertheless, tensions arose between groups, as well as within them. Against expectations, Stage 1 of the cycle, sharing ideals, did not elicit as many tensions and disagreement as Stage 2, establishing the facts. The 'facts' of Stage 2 of the learning cycle caused the greatest disruption. Communities, experts and organisations disputed each other's 'facts'. This was an inheritance from the scientific era, where only results from explicit observations could be considered acceptable. The wider the range of individuals involved, the greater the increase in mutual acceptance of facts. As David Bohm might have said, dialogue between the parties was needed to convince warring groups to move beyond their contrasting versions of 'the truth' (Bohm 1996).

The first workshops were arranged as round tables whose 9–11 members were drawn from each of the knowledge compartments. The aim of completing each cycle was to arrive at collaborative action on their chosen topic. The topics ranged from individual concern for the environment, a city concerned with its environmental health status, the development of a local government region, national environmental sustainability issues, workshops on transformational change and more (Brown and Lambert 2012).

The workshop process began with invitations to members of each of the interest groups involved in the selected issue. Those that accepted were asked to agree on a focus question that involved them all. It was sometimes difficult to ensure that all the groups were represented. As a result, some of the workshops became role plays in which members adopted the personas of the different social groups. It was interesting that, when using this method, members usually adopted the same positions as the actual group members in other workshops. This suggests that the socially-constructed groups were clearly recognized across the society.

The outcome of the second round of workshops confirmed that Western society was fragmented into a set of strongly bounded knowledge silos of knowledge. In the workshops, each group exhibited its own pattern of responses and personal fiefdoms. The boundaries were so strong that group members often clung to their allotted roles even in the face of contradictory evidence. This led the LSP team to move to workshops in which members were asked to respond to each of the steps of the cycle as individuals, rather than as members of pre-existing interest or a knowledge sub-cultures.

In this third series of workshops, with participants as independent individuals, the individuals sometimes identified with one of the pre-existing groups (community, experts and organisations) and sometimes spoke entirely on their own behalf. In the previous workshop rounds, knowledge sub-cultures and interest groups could split internally into opposing parties, thus increasing the tension. Experts regularly referred to their own disciplines, even though the traditional mono-disciplines are now giving way to multidisciplinarity or transdisciplinarity. Organizational representatives pursued their own agendas. Overall, individual responses were more likely to break new ground, outside the fixed positions of other members of the group.

The most significant difference identified in the first and second rounds of workshops was between the collective thinking of the socially-constructed closed groups, and the collective thinking of open-minded independent individuals. To follow this further, a third series of workshops, with the same aims and still using the same collective learning design, asked the participants to respond to their chosen topic as individuals with their own knowledge and experience. The workshop reports below are examples of the introduction of individuals to the collective learning cycle.

18.3 Collective Learning Spiral: Individuals and Groups

After some years presenting the LSP workshops, a distinct pattern emerged. The proposed ideals would change during the workshop. Fresh topics for discussion arose after mutual learning among group members. The workshop members speaking as individuals were happy to consider a range of options for cycle Stages 2 (facts) and 3 (ideas). There were workshop members who were not happy with the divisions into knowledge sub-cultures, and others who preferred it. Yet others wished to marry the thinking of the knowledge sub-cultures and their own individual thinking. Despite all this, after several rounds of workshops it became possible to identify the multiple ways of thinking held in common by all individuals (Brown and Harris 2014):

Biophysical thinking: the physical environment in which an issue was set. Arrived at by observation, experience and reading formal reports.

Socio-economic thinking: the social environment, including cultural rules and the socio-economic system (a prevailing emphasis in Western culture). Arrived at through personal involvement, and the narratives and memories of your community.

Ethical thinking: the principles governing relationships between individuals and between individuals, environment, and society. Arrived at through a sense of right and wrong, in relation a personal commitment to a way of life or a religion.

Artistic thinking: sensitivity to the patterns in natural and in social systems, arising from the capacity for inspiration and creativity within each human being. Arrived at by both expressing, and rebelling against the surrounding cultural norms.

Sympathetic thinking: recognizing a shared understanding with another human being or group, or with another species. Arrived at through openness, trust, and shared experience.

The individuals' collective thinking workshops differed in several ways from the socially-determined groups of interest and from the knowledge sub-cultures. In the latter two workshops, participants tended to look for authority from their own areas, but in the individually-based workshops, participants drew on both groups as well as a wide range of other relevant sources. Individuals had the capacity draw upon interconnected biophysical, socioeconomic, ethical, artistic and sympathetic ways of thinking. They made their personal contributions to the chosen topic from these multiple ways of thinking, like a set of doors leading to a common-room (Hocking et al. 2016). Individuals also interpreted the focus question for the workshop in different ways, while the groups were more likely to keep to their agreed focus.

The individual patterns of response during the four stages of collective learning followed closely those of several contemporary writers. The types of intelligence identified by Howard Gardner in 1983 (intrapersonal, interpersonal, musical, logico-mathematical, kinaesthetic, spatial and linguistic) match closely those of the multiple ways of thinking in independent members of the Local Sustainability Workshops. This is also true for Gould (2003) and Berlin (1967). The difference is that the concept of intelligence is usually related to cognitive capacity while collective thinking in individuals involves feelings, experience and imagination. Other authors who cover the same ground are Mary Midgely and Helga Nowotny, who describe individual thinking in the context of the socially constructed knowledge that Nowotny calls socially robust knowledge (Midgely 1990; Nowotny et al. 2001).

Another exploration of collective thinking in its social context is that of Isaiah Berlin. His seminal essay, “The Hedgehog and the Fox” identifies two ways of thinking. He follows the ideas of the Greek author who wrote of the hedgehog who thinks of everything he hears and sees as part of one big thing, and the fox who runs hither and thither, looking for anything he can find. Berlin calls Shakespeare a fox, and Tolstoy a would-be hedgehog (Berlin 1997).

Similarly, in the Local Sustainability Project study, two parallel streams of multiple ways of thinking emerged. The first was a set of knowledge sub-cultures and the other was the collective thinking of independent individuals (Table 18.1). Not surprisingly, there were connections between the two, given the same individuals could both speak for themselves and access socially-determined knowledges. The case studies below reveal the influence of the long-standing dominance of biophysical evidence in both streams. The conflict which so often erupted when the groups were responding to Stage 2 (the facts) of the collective learning cycle was partly due to the collision between open-minded individuals and the compartmentalized groups.

Parallels between closed groups and open individual ways of collective thinking are shown in Table 18.1.

Table 18.1 Ways of thinking: open and closed (Brown and Harris 2014)

Ways of thinking	Closed socially-defined groups	Open independent individuals
Biophysical:	Quantitative descriptions	Quantitative and qualitative
Individual:	Identity based in groups	Unique personal identity
Social:	Self-contained groups	Community partnerships
Expert:	Monopoly frameworks	Multiple knowledge sources
Ethical:	Group-defined rules	Personal principles
Artistic:	Consistency	Creativity
Sympathetic:	Within one’s group	With other individuals

Overall, the findings from the Local Sustainability Project confirmed that the differences between the groups and the individuals could best be treated, not as opposites, but as a relationship in which the group thinking and the individual thinking sometimes extended, and sometimes rejected, each other. There were many similarities to double and triple loop learning, as described by Bateson (1973) and Bawden (1998). In this case learning from the workshops is enhanced by reflecting on the learning (loop 1), and made even richer by reflecting on the reflections (loop 2). Members of the socially-defined groups were more likely than the independent individuals to continue the tradition of requiring physical evidence, and looked to authorities for direction. In individual thinking, multiple ways of thinking, subjective feeling, and personal experience were given full weight.

In Table 18.1, for individual thinkers, biophysical thinking with its observations and measurements needed to be confirmed by personal judgement. Their socioeconomic thinking looked for advice from a range of community sources, with a strong economic component. Ethical principles reflected the influence of society and personal commitments to a standard of behaviour. Artistic sensitivity was an inner dimension, recognized by patterns, for the individuals in the study. In Western cultures, artistic dimensions of thinking are often not acknowledged. One of the most powerful dimensions was the allocation of sympathy. In socially determined cases, sympathy of participants with their own groups was often stronger than sympathy with other individuals, even their own clients. Individuals gave some very interesting stories of sympathy and absence of sympathy in a range of circumstances.

Three summaries of collective learning projects identify the contributions from the formal groups and from individuals. The three examples review collective learning cycles at the local, regional and national scales. The following notes were presented to the case study groups for confirmation before publication. The notes are extracted from Brown and Lambert (2012).

Case Study 1: Sustainable Land Management

In the case of a region of exhausted agricultural and natural resources, the focus question was: *Can this region change their farming customs to support sustainable agriculture?* Those who came together to answer the question were drawn from 10 rural industries, five sub-regions, government agencies, regional opinion leaders, and the coordinating Catchment Committee who funded the study.

What should be?

Seven characteristics of a good life in the region: managing change, having accountability systems, using market mechanisms, working with whole supply chain, establishing collaborations and achieving on-ground sustainability. Individuals wanted to find a life-work balance, and work with others to making the system work.

What is?

Each of the round table group members described a different reality, bringing a deeper understanding of the region's strengths and weaknesses as a whole. There was considerable disagreement what those strengths and weaknesses were.

What could be?

Change strategies that could satisfy the seven characteristics of a good life in the region; changes in thinking that included thinking for oneself.

What can be?

Each industry and region described strategies for sharing innovative ways in managing change on the ground, including strategies for changing from existing ways of thinking. Individuals replied that they would extend their own involvement and commitment to behaviour change, learning from the others.

P.S. Actions following the collective learning cycle led to greater collaboration between the interest groups.

Case Study 2: National Sustainability Research Programme

For the future-oriented research team, the focus question was: *How can we develop a future research programme based on the findings of our past programmes?* This brought together research interests from city and country, government and industry, a wide range of specialists and practitioners in sustainability programmes.

What should be?

Answered almost unanimously by those from structured groups and as individuals as “greater collaboration among all the members of the policy community”.

What is?

This question produced dramatic anecdotes of lack of collaboration and few positive examples.

What could be?

The group developed a comprehensive agenda of unrealized opportunities for collaboration; members from individual, community, specialized, organizational and holistic ways of thinking all started from their own base. Individuals talked of potential and existing conflict, and strategies such as dialogue and open space technology.

What can be?

A policy proposal was put to government to fund an action research programme promoting collaboration right across the research sector, focused on sustainability in a wide-ranging context: technical, financial, social, educational, legal and more.

P.S. Research funds enabled the collection of further examples of collective thinking.

Case Study 3: Local Response to Climate Change

Following a public community meeting, a community team followed the LSP collective learning process to run a workshop on a local response to climate change. Another community meeting was held, and the next cycle continued the success of the previous cycle.

Focus question: *How best to apply a collective social learning process in a social change workshop?*

What should be?

Team members answered: "Clarity of purpose and shared interest in the outcome; ensure participants are clear about what they are there for and have faith in the process". Individuals asked team members to establish mutual respect, honesty in personal aims for the workshop and clear lines of responsibility.

What is?

Each knowledge sub-culture's skills, experiences and goals area divided, with groups angry at having to share their mental space There were existing conflicts of interest and a lack of trust and cooperation between groups. Individuals attempted to apply the rules of dialogue, and provide a peaceful ambience, and mutual listening, accepting that participants were likely to be competitive, self-centred and alienated.

What could be?

A climate of creative imagination, and hopefulness; buzz of exciting new ideas; people profoundly catalyzed to think outside their square. Individuals suggested finding time for reflection; increasing being confident to express a range of creative, alternative, 'way out' ideas, including making unusual links and connections.

What can be?

We can be a fantastic community, working from our own skills base and at the same time in a collective team process; together we can bring change. We need to share our collective techniques/tricks e.g. 'learning circles'; strategic futures planning; learn from what happened but do it better; follow-up with a second series of vision workshops. Individuals wanted to do something differently with music and the arts.

P.S. A follow-up workshop involved each individual making drawings for their own idea of the changed community and explain their drawings to the other participants.

18.4 Collective Learning for Whole-of-Community Change

As part of a collaborative action research project, Local Sustainability Project teams took part in the collective learning cycles. For over 300 workshops, the outcomes of each learning stage in each cycle were recorded and shared among the participants. The comments throughout this chapter have been drawn from these records. One of the lessons was that the links between the stages were as important as the stages themselves. The outcomes for each cycle resembled a collage in which all contributions contributed to a shared understanding. This result was not unlike completing a jigsaw pattern in which the pieces are predetermined and made to fit. The participants needed to work together for a shared understanding (not a consensus), creating what David Bohm calls 'learning from difference, not more of the same' (Bohm 1996).

In developing the process of collective learning, it became clear that it was essential to follow the four stages in a definite order. Starting with strongly-felt ideals for *what should be* requires that all participants listen to each other's ideals rather than fight about them. The next stage, *what is*, established the information necessary to help work towards realising the ideals, rather than merely describe current problems. In the third stage of each cycle, blue sky thinking about *what could be* allows all the participants to work together and to go outside their comfort zones. For the final stage of each collective learning cycle, *what can be*, the Project team assists collaborative groups to pursue practical projects towards their visions. By the end of each workshop, after the participants have moved to collaborative action, they move into another cycle, turning the process into a spiral.

Relationships between knowledge, learning, and power are so intertwined that a separate discussion is needed to apply them explicitly to each learning cycle. In this chapter, we have explored the ideas behind individual and groups collective learning cycles in relation to intentional transformational social change. The emphasis throughout has been on experiential learning, 'learning by doing', and on the importance of welcoming diversity. Currently, there is a practice of clinging to previous perspectives (Table 18.1). On the other hand, it became apparent that open collective learning is needed to take full account of every individual's biophysical, social, ethical, artistic, and sympathetic ways of thinking about the future of their communities and the world in which they live.

Creative individuals and compartmentalised groups have built walls to protect their different ways of interpreting the world. Barriers include: prejudice, power hierarchies, lack of respect, avoidance of conflict, and skewed allocation of resources. To dissolve these walls would require a considerable shift in the way collective learning is perceived. It is not a simple process, and nor is it necessarily welcomed by all concerned.

In this study, each collective learning cycle needed tools for achieving collective thinking, such as dialogue, conversation, consultation, conflict resolution, personal reflection and more. Three rounds of workshops offered insights into the collective learning patterns of interest groups, knowledge sub-cultures, and individuals in turn. The Local Sustainability Project team concluded that a collective learning spiral bringing whole-of-community change requires a fourth dimension, in which the thinking of fixed interests, and established knowledge sub-cultures, becomes grounded by open-minded and independent individual thinking.

Acknowledgements My thanks to my long-time collaborator, John Harris, writing group members Craig Ashurst, Diana Dibley and David Marsh and two anonymous referees for their valuable contributions to this paper.

References

Adam, B., Van Loon, J., & Beck, U. (2000). *The risk society and beyond*. Cambridge: Cambridge University Press.

Ansell, C. K. (2011). *Pragmatist democracy: Evolutionary learning as public philosophy*. New York: Oxford University Press.

Aslin, H., & Brown, V. A. (2004). *Towards whole of community engagement. A practical toolkit*. Canberra: Murray Darling Basin Commission.

Bateson, G. (1973). *Steps towards an ecology of mind. Collected essays in anthropology, psychiatry, evolution and epistemology*. St. Albans: Paladin.

Bawden, R. (1998). I as in academy: Learning to be systemic. *Systems Research Journal, 12*(3), 229–238.

Berlin, I. (1967). *The hedgehog and the fox. An essay on Tolstoy's view of history*. London: Wiedenfeld and Nicolson.

Berlin, I. (1997). The hedgehog and the fox. In *The proper study of mankind* (p. 436). New York: Farrar, Straus and Giroux.

Bohm, D. (1996). *On dialogue*. London: Routledge.

Boyden, S., Millar, S., Newcombe, K., & O'Neill, B. (1981). *The ecology of a city and its people: The case of Hong Kong*. Canberra: ANU Press.

Brown, L. (2005). *Vital signs*. Washington, DC: World Watch Institute.

Brown, V. A. (2008). *Leonardo's vision: A guide to collective thinking and action*. Rotterdam: Sense.

Brown, V. A. (2015). Utopian thinking and the collective mind: Beyond transdisciplinarity. *Futures Journal, 65. Advances in Transdisciplinarity 2004–2014*, 209–216.

Brown, V. A., & Harris, J. A. (2014). *The human capacity for transformational change: harnessing the collective mind*. London: Routledge.

Brown, V. A., & Lambert, J. A. (2012). *Collective learning for transformational change. A handbook for action*. London: Routledge.

Brown, V.A., Harris, J.A. and Russel, J. Y. (2010). *Tackling Wicked Problems through the Transdisciplinary Imagination*. London: Earthscan.

Cohen, L. (1972/1992). Anthem. In *The future*. New York: Sony.

Dewey, J. (1910). *How we think*. Boston: Heath.

Fleck, L. (1979). *The genesis and development of scientific fact*. Chicago: University of Chicago Press.

Friedman, T. L. (2000). *The lexus and the olive tree*. New York: Anchor Books.

Freire, P. (1996). *Pedagogy of the oppressed*. Harmondsworth: Penguin (orig. 1970).

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Gould, S. J. (2003). *The hedgehog, the fox and the magister's pox: Mending the gap between science and the humanities*. London: Harmony Books.

Hamilton, C. (2017). *Defiant earth. The fate of humans in the Anthropocene*. Crow's Nest, Sydney: Allen and Unwin.

Hancock, T. (2016) Governance for health in the Anthropocene, Melbourne: Deakin University.

Hocking, V. T., Brown, V. A., & Harris, J. A. (2016). Tackling wicked problems through collective design. *Intelligent Buildings International, 8*(1), 24–36.

Jung, C. (1964). *Man and his symbols*. New York: Doubleday.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall, New Jersey.

Lewin, K. (1943). Defining the "field at a given time". *Psychological Review, 50*, 292–310 Republished in *Resolving social conflicts and field theory in social science*. Washington, DC: American Psychological Association.

Local Sustainability Project. (1995–2015). Canberra: Fenner School of Science and Society, Australian National University.

Midgley , M. (1990). *The myths we live by*. London: Routledge.
Nowotny H., Scott P. and Gibbons, M. (2001). *Re-thinking Science. Knowledge and the Public in an Age of Uncertainty*. Cambridge, Cambridge University Press.
Passmore, J. (1970). *The perfectibility of man*. New York: Charles Scribner's Sons.
Piaget, J. (1951). *The child's conception of the world*. London: Routledge.
Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*, 155–169.

Chapter 19
Philosophical Reflections: A Coda

Paul Gibbs

All men [people] by nature desire to know

Met 980b22 – opening line of the Aristotle's Metaphysics

19.1 Introduction

We live in a world that confounds simple analysis. It is a place where things change and turn messy, where chance and causation are confused, and where truth and knowledge are empirical, perceptual or just faked. It is a world of many realities that are difficult to live in where our own destructive history has led us to control rather than to reflect, appreciate, love or be humble. This is a view shared by many of the contributors to this book. They place complexity at the centre of the issues that the world faces and see it manifest in a number of recurring themes, from which I have chosen knowledge and practice to consider in this final chapter. There can be no Platonic right answer for—either there just isn't one, or we are not God like enough to be able to find it. Prehaps not settling on a definitive notion of transdisciplinary, the processes of its knowledge creation and it definition allows for the richness, intellectual flexibility and the humility to accept we might just not be able to know but can and must act. Our agency should result in outcomes that help others in multifaceted ways. The pedagogical tasks that follows from such a premise will be always need to be treated carefully and with sincerity.

The contributors also suggest different epistemological and ontological stances to the idea of transdisciplinary knowledge, its form and it emergence in pedagogical practice and curriculum design. Such divergence illustrates the nature of an emerging notion of the phenomena of transdisciplinary knowledge one where the metaphysics of western understanding is questioned and the implementation of practice

P. Gibbs (✉)
Centre for Education Research and Scholarship, School of Health and Education, Middlesex University, London, UK
e-mail: P.Gibbs@mdx.ac.uk

D. Fam et al. (eds.), *Transdisciplinary Theory, Practice and Education*,
https://doi.org/10.1007/978-3-319-93743-4_19

re-ignite the cultivation of teaching and researching as *phronesis*, *phantasia,* and *parrhesia* which orients inquirers toward moral and intentional truth-telling practices that resist simplistic renderings of "criticality and overly technical understandings of research" (Pickup 2016: 178).

Such an approach has resonance with many (Ross and Mitchell, Chap. 4 in this book), who highlight that much of the difficulty is in approach, in engagement and in revealing the problems that are cloaked in framings of past epochs. Knowledge is fragmented, specialized, linear and scientific. It ignores or denigrates other forms of knowledge in its control of knowledge and truth. These authors argue against this, and it is a view shared by many of the contributors, including myself. Many argue for new ways of envisioning knowledge and knowledge creation practices, attributing the lack of a solution for our most pressing and fundamental problem of respect for our cosmos to a structuring of knowledge into powerful silos and hierarchies. Moreover, these ways have a commonality in that they privilege abstract theoretical reasoning in certain acceptable paradigms. Knowledge is thus controlled by the powerful, and personal prudence prevents the permeation of ideas from discipline to discipline because of the impenetrable and artificial barriers of research practices, closed belief systems, restricted vocabularies/grammars and the failure of collaborative conversations.

This fragments what is knowable, and the status of knowledge is used to exclude other forms of knowing such as indigenous knowledge. This privileging is problematic for the authors in this book as, I will suggest, it was for Aristotle and for other Ancients. I want to propose that in the search for knowledge that is relevant, practical and efficient, Aristotle has more to offer the reader of this book than might first be considered, especially (and, I will suggest, wrongly) if he is held responsible for the claims of the priority of theoretical over the practical, regardless of circumstances. I will argue, with considerable help from Eikeland (2008) and Papastephanou (2010, 2013), that his understanding of knowledge or *gnosis* is much more nuanced than is implied in the way his work is generally discussed Moreover, I will argue that there is a collective, collaborative core to his understanding of knowledge <u>which holds that it is</u> better created when with others than when alone in contemplation It is his more complex relational notion of knowledge that fits a transdisciplinary approach to difficult problems and their understanding better than a disciplinary, multidisciplinary or interdisciplinary approach (see Klein, Chap. 2, for an important clarification of these terms).

19.2 An Emergent Concept

The emergence of transdisciplinarity has been in response to the often failed attempts of closed-system, discipline-based approaches to solve complex social problems (various reports and definitions can be found in projects reported by the OECD, UNESCO and EU but see also Chap. 3 of this book by Neuhauser). These failures are often contingent upon disaggregated notions of knowledge (*gnosis*) into epistemology and practice, and are compounded by the failures of ontological incongruities evident in discipline-based approaches. Such approaches do not need to be confined to large, seemingly insurmountable social problems, but apply equally well to issues in emergent worlds that seemingly defy traditional, methodologically inspired empirical investigation.

Among the boundary-spanning definitions of transdisciplinary research that emerge from and are applied to transdisciplinary problems, any attempt to resolve value-laden issues requires judgment of the practical alternatives that affect others. They are not theoretical but practical, and are informed by the onto-epistemic principles contextualized in ethical and political contexts (see Golja and colleagues' discussion in Chap. 13 of this book on the ethical challenges relating to political and epistemological dimensions of professional learning and industry engagement). These concerns are too important to be hampered by the constraints of disciplines, and the forms of knowledge and the veracity that they sanction. The knowledge needed is both of the means to solve the problem and the goal of the solution. Knowledge is in the liberation of new and imaginative understanding from those meanings available under a notion of causality-predicated epistemologies within the closed system of the presenting problem. It is the understanding of the objects and the structured reality of open social systems that gives rise to the causal powers to which we attribute the relationship of agency and structure. It is in this sense that I explore (necessarily in some detail) what Aristotle wrote on knowledge, which seems to me be to be transformative as well as transdisciplinary and to have resonance with the claims made by the contributors to this volume.

19.3 Aristotle's Knowledges (*Gnoseology*)

The literature, especially that which relates Aristotle to knowledge, often rigidly separates just three forms: *episteme* (crudely, theoretical and empirical), *techne* (practice) and *phronesis* (wise use of these) (Flyvbjerg 2001; Dunne 1993; Polkinghorne 2004). Yet this categorisation is not found in the writings of Aristotle. In his work, according to his notion of understanding natural occurrences, a thing that can be knowable comes to be known via epistemological methods. However, we need to note that such methods are not appropriate for things that do not have the characteristic of stability, so epistemic methods cannot be a universal way of knowing. The misreading of Aristotle in this way has meant that forms of scientific investigation which are appropriate for a specific field of study have grown into structures, customs and practices. These structures, customs and practices fragment knowledge into separate disciplines, and act as hegemonic forces that assume all knowledge takes such a form. This approach argues that to know is to transform as much as possible into a universal good knowledge, endorsed by method. This is not what Aristotle sought, for he saw different forms of knowledge in relation to specific kinds of activity and passivity in the *Topics* (Top 145a 13-15).

Aristotle introduced his ways of knowing in Book VI of the *Nicomachean Ethics* (EN 1139a 21-b5), but treats knowledge throughout his works as a multidimensional gnoseology, making it a much wider category of knowledge than *episteme*. As Papastephanou observes, a 'more nuanced and comprehensive study of Aristotle shows that, despite mentions of hierarchies of knowledge that reflected social commitments of a realist and adaptive kind and were inconsistent with his whole philosophical architectonic, Aristotle not only described but also valued other knowledge, beyond what corresponds to contemporary science' (2013, p. 114) (I will not pursue this here, but see, for an example, Johnson's 2015 discussion of theoretical, and productive, architectonic and manual sciences, and Dehart's 1995 discussion of the convergence of *praxis* and *theoria*). As Eikeland observes, 'although modern epistemology can be traced back to both Plato and Aristotle, the old philosophers themselves, especially Aristotle, were far more differentiated in their thinking about knowledge' (2007, p. 348).

19.3.1 Gnoseology

Aristotle's *gnoseology* is determined by the fact that the knower is always related to the known in multiple ways. He declares that 'there are three branches of study, one of things which are incapable of motion, the second of things in motion, but indestructible, the third of destructible things' (Phys 198a30-31). So, rather than being free from practical or experiential reference, knowledge is, in its various modalities, inherently relationally defined; that is, it is dictated by the object of its concern (Eikeland 2008, p. 51). Those segments of reality that are not produced, modified or developed artificially invite theoretical ways of knowing. On the part of the knower, the main preoccupation with them is the effort to understand, explain, interpret or critique them. This effort may result in *episteme*; that is, in a systematically searched, adequately stabilized and secure knowledge about external things that displays, to a large extent, some regularity. In this sense, activities other than science might be considered *episteme*.

However, in in his *Metaphysics* (Met 1025b3-1027a28, 1064a10-19), Aristotle 'indicates that an episteme can be either *theory*, *productive* or *practical*, and they can all be about things that are stable for the most part' (Eikeland 2008, p. 88). And there is yet another crucial distinction. *Praxis*, both as performance and as a way of knowing, is still different from an *episteme practical* as a knowledge form. Likewise, an *episteme productive* differs from *poiesis*. In other words, *praxis* and *poiesis,* as such, are not *episteme*. Nevertheless, *poiesis* and *praxis* 'are still forms of *gnosis*' (knowledge). The crucial implication for the sources of the epistemic is that an *episteme* can be based on perceptual observation or on 'performative observation, on *praxis* and *poiesis*' (Eikeland 2008, p. 88). In all cases, relationality makes the act of seeking to know primarily an engagement with the world rather than an aloof, distant or manipulative operation. Papastephanou suggests that what Eikeland theorizes as *gnosis* 'appears to be a wider category of knowledge than episteme, since gnosis comprises, amongst other things, also perception (aesthesis), habituation (hexis) and even self-conscious human living' (2013, p. 113).[1] *Gnosis* is thus broader than *episteme*, and it involves both epistemic and non-epistemic forms of political and practical knowledge.

Further investigation of Aristotle's *gnoseology*, according to Papastephanou (2013), reveals that, in addition to Aristotle's theory of knowledge as comprising *theoria*, *poiesis*, and *praxis*, there is textual evidence that he considered as primarily complementary knowledge forms (Phy 202a21-b29) the following: *khresis* (using) (Phy 194a33-b8); *politis* (1256a4-10); and *pathos* (passivity, receptivity or reactivity). As Eikeland remarks, unlike *poiesis* and *praxis*, *khresis* 'relates to externalized objects, but merely as instruments, not as material, i.e. with ambitions of only using them, without changing them in any way' (Eikeland 2008, p. 90). As to *pathos*, it is the knowledge form that is based on the experience of being acted upon, directed or formed from without, and it covers a wide spectrum of experiences such as passivity, receptivity, reactivity, emotional affection and even suffering. Interestingly and, again, much against modern assertions that in Aristotle knowledge is isolated from emotion and will, *pathos* is not to be excluded in meaning, but it is to 'be formed and tempered through praxis' (Eikeland 2008, p. 91). From all the above, we see that instead of imposing an impoverished notion of knowledge Aristotle's *gnoseology* comprises a wide spectrum of modes of knowledge that it associates with a nuanced and rich account of relational ontology. And since all various ways of knowing have their own, specifically ethical–political implications, we must not lose sight of the fact that, for Aristotle, our modern ethical and political neutrality of knowledge does not hold (Papastephanou 2010).

Aristotle does not argue that all knowledge has to be of a single fundamental form, but neither does he argue that all knowledge is equivalent in use. In the table that follows (Table 19.1), Eikeland (2007, p. 348) provides a more subtle reading of Aristotle, arguing for two forms of *theory* and *episteme* that have similarities in their theoretical nature. The first is *theorisis* (or *Episteme 1*), which relates to the knowledge of observation of entities that exists without interventions and is deductive. The objects studied are outside us and change naturally. We can use theory and models to understand such entities; regardless of their relevance to the object, they obtain their credibility through their prediction of the object's activity. This model is the dominant idea underscoring the scientific paradigm, and is a major cause of the malaise of higher education! The second form, *Episteme 2*, is *theoria.* This is the investigation into the known and the knower simultaneously, and changes through knowing. It is about belief, opinion and experience. There is also a division between *Praxis 1* and 2. The former, alongside *phronesis,* is action based, whereas *Praxis 1* is again related to oneself. *Pathos* is knowledge created by being passively affected by external sources, and *khresis* is skill in the use of things.

[1] Here, I am drawn to consider the five socially constructed and nested knowledges proposed by Brown in Chap. 18.

Table 19.1 Aristotelian ways of knowing, after Eikeland (2008, p. 348)

Basis	Way of knowing	Associated rationality	English equivalent
Aısthesis (perception)	*Theorises (episteme 1)*	Deduction, demonstration, didactics	Spectator speculation
	Pathos	Feeling, intuition	Being affected passively from the outside
Imperia (practically acquired experience)	*Khresis*	*Tekhne* (calculation)	Using
	Poıesis	Construction	Making, manipulating
	Praxis 1	*Phronesis* (deliberation)	Doing: virtuous performance
	Praxis 2	Dialectics/dialogue	The way from novice to expert, from tacit to articulate practice; training for competence development and insight
	Theorıa (episteme 2)	Dialogue, deduction, deliberation	Insight

19.3.2 Phronesis

I now turn to the notion of *phronesis,* which is concerned with action with the intent of achieving good (however that might be defined), but the culture of its occurrence is not absolute, as in the sense of s*ophia* (knowledge of the ultimate). I do this as I want to suggest that it could be the central knowledge construct for transdisciplinary studies. It brings together notions of knowledge, without demeaning them, to inform action. It is action that needs judgement in ways that we can control. We decide upon and choose (unlike *episteme*, which deals with things that vary, and within themselves change) within a specific context with a specific purpose; that is, we pursue ends and objectives within themselves such as justice, whereas *techne* is concerned with making, changing or bringing into existence something, and judgement allows for different ways of response. Aristotle settles on *phronesis* as being ‘a true and reasoned state of capacity to act with regard to the things that are good or bad for man. For while making has an end other than itself, action cannot; for good action itself is its own end’ (EN 1140b3-5). In this, *phronesis* is about human goods and about opinion (*doxa*), not *episteme*. It is not just a skill or an art form, but is associated with an individual worldview and the ability to guide people towards actions that are seen to be collectively good (Aristotle referenced Pericles in EN 1140b7).

Actions are good, not because they are consistent with an abstraction, but because they are consistent with a collective context. An analogy might be Western versus Chinese medics. Crudely, the latter see symptoms and make judgments about the reason/cause of the malady and, on the basis of the whole circumstances as presented, not just the physically embodied, propose an action designed to resolve the problem. Different solutions in the way in which the problem is perceived and conceived determine the resources at hand to serve to solve the problem. In Western cultures, our approach is often not sufficiently comprehensive to cure a fever in someone living in poor housing, as it will not resolve the underlying cause—the housing—despite taking account of it in the proposed treatment. However, as a political rather than a palliative force, medicine can indeed achieve this, yet demands wider transdisciplinary skills.

Put differently, the kinds of experiences in which *phronesis* comes into play are understood only insofar as we actually live through them. For Bernstein (1996) as for Gadamer, whether in skills or ideas, mere technical competence falls short of the wisdom of *phronesis*, for it is with wisdom that actions can gain their moral direction, and practical wisdom supports education. As Gadamer points out, a *phronimos* – one who has practical wisdom – is 'always in the situation of having to act in exigent circumstances. The image people have of what they ought to be, their conceptions of right and wrong, of decency, courage, dignity are always presupposed in decisions they are called upon to make' (1975, p. 283).

19.4 Collective Wisdom: The Political Notion of *Phronesis*

According to Aristotle, even the wisest individual is better able to think with the aid of others. He argues, in EN 1155a15-16, that: 'with friends men are more able both to think and act'; in EN1177a3 that contemplation can be 'enhanced by fellow workers'; and in Pol 1287b13 that 'two men are better than one'. Yet this collaboration needs to be amongst those who focus on critical thinking in order to facilitate the recognition, acquisition and application of individual and collective knowledge. They need to have the skills and abilities needed to achieve specific outcomes of significance to the thinker in the context of the problem. To make this work, participants in the decision must be respected as equals, as is the knowledge that they bring to the discussion. Moreover, they must seek relational notions of the not disciplinary absolutes l. (Jacobs et al. in Chap. 17 in this book) show how collaborative transdisciplinary design of public infrastructure can be re-imagined for the greater benefit of all). The collaborative is not discriminated against in terms of the form of knowledge that they bring, for all forms of knowledge are valuable and to resolve the problem from within the *gnosis* that is available to them in ways that are integrative, transformative and collaborative. To denigrate any knowledge of the holder of justifiable thoughts is to reduce the potential for finding a to one of prejudice and ascribed authority.

In Chap. 5 of this book Prior and Capan open the discussion of transdisciplinarity by arguing that it creates an opportunity for collective thinking beyond or across disciplinary boundaries, which not only invites the unthought, but also for some disciplinarians invites the unthinkable: the idea that disciplinary boundaries are porous. This is an approach which chimes well with Nicolescu's challenging and now seminal work reprinted in (Chap. 6 of this book).

In Chap. 12 of this book Pearce and colleagues illustrate how different realities and diverse knowledges can be brought together to create a learning space where cognitive, affective and embodied learning can flourish in way that would seem to cast an Aristotelian shadow over them. A recognition of the richness of knowledges that do not find expression in the forms of the contemporary Western paradigm was not an Aristotelian goal, and the importance of indigenous frameworks as ways of being discussed by De Santolo in Chap. 14 of this book would have found a home in Aristotle's gnoseology (I am thinking of Top 121b 35/36, where Aristotle refers to virtue and knowledge, and argues that they fall under the same genus: 'for each of them is a state and a disposition').

To establish what the problem might be, Aristotle speaks of first principles that can be realized by (an extended quote is needed):

> induction, some by perception, some by a certain habituation, and others too in other ways. But each set of principles we must try to investigate in the natural way, and we must take great pains to determine them correctly, since they have great influence on what follows. For the beginning is thought to be more than half of the whole, and many of the questions we ask are cleared up. We must consider it, in the light not only of our conclusion and our premises, but also of what is commonly said about it. (EN 1098a3-10)

In this passage, the multidimensional forms of knowledge, from scientific to traditional, are respected, collated and considered in the development of a course of wise action. Moreover, given that this action is likely to engage with a specific community or *polis,* the action must consider the good in the deliberation of agency. Thus, the decision and the ensuing action are consistent with the needs of both the community and its individual members. There is, of course, a caveat to this position. Should the community or *polis* lack excellence in its policy and practice (i.e., if it is corrupt), then the criteria for making decisions will be perverted and the outcome will be fraudulent. Thus, the ethics and politics of action are central to the evaluation of action proposed through the widest collection of information and collective, collaborative decision-making. Crosby, Fam and Lopes provide an excellent example in their Chap. 9 of this book of collaborative participation of design academics, students and industry experts in designing a university's on-campus food waste management system.

This process is an educative one where, through education and the habituation that come with it, one becomes familiar with and understands what constitutes virtuous action. Neuhauser (Chap. 15 of this book) confirms that this can be difficult: to ignore communities of practice and the intercultural dimension that they offer may inhibit the core of collaborative practice. Riedy and colleagues' discussion in Chap. 10 of this book points to the problems of habituation and offers insights into the supportive community of practice developed at the Institute of Sustainable Futures. Clarke and Ashhurst in Chap. 11 of this book present a different yet aligned discussion of a socio-material assemblage as the formative principle of their learning in a collaborative pedagogical context. Leimbach and Armstrong's discussion in Chap. 16 of this book confronts the challenges of the incommensurability of forms of knowledge never acknowledged by Aristotle. This concerns perhaps the most distinctive shift in the view of Aristotle as an embracive gnoseologist rather than a separatist. The art–science divide is articulated and the authors extol the virtue of collaboration, respect, creativity and creation. Both Chaps. 12 and 16 of this book advocate both the need for an ethos of authenticity in transdisciplinarity approaches, and the need to nurture and protect them. They do this by arguing for a form of community whose values and standards are suggested in the political context of *phronesis* (Surprenant 2012). Surprenant proposes that the members of a community need to be familiar with the principles of the community for the *phronimos* to flourish and be recognized. Further, where the characteristics of these principle are not well ordered, members of the community associate ‘what is good with what is in their own interest rather than associating it with what is in the interest of the polis (community) as a whole’ (Surprenant 2012, p. 226). It is through education and the habituation that comes from participation that one can become familiar with the nature of a community and its forms of collaborative knowledge and, in so doing, understand what constitutes worthy and virtuous behaviour (see Aristotle’s account in EN 1036a).

19.5 Collaborative Conversations in Transdisciplinary As Learning and Research

The forms of collaborative resolution that are central to the development of the ideas in this book are at the core of transdisciplinarity. Indeed, the nature of collaborative learning is conversations with others that, to quote Brown in Chap. 18 of this book, ‘need to take account of the multiple ways of thinking, both open and closed’. I might add an ontological dimension to this important observation. Bruffee calls these forms constructive, reacculturative conversations that require ‘willingness to grant authority to peers, courage to accept to oneself granted to oneself by peers, and the skills in the craft of interdependence’ (1999, p. 12). Such intellectual excellence lies, in the words of Oakeshott (1975/2003), in an initiation into ‘the conversation between the generations of mankind’ in which neophytes come to appreciate the ‘different voices’ of poetry, of philosophy, of science, of history, which constitute that conversation. Central to this premise is that we think because we can talk, and thought is thus a social, collaborative and interdependent activity. This point is made in the form of grammar, where the knower and the known coincide (Eikeland 2007, p. 351). It is through the nature of grammar (coherent in use, where what is common is known) that in new fields of transdisciplinary practice there is a need for deliberation or *phronesis*, trying to find out how to act in the most effective way whilst respecting rights and obligations in context. It is through education and virtue that this process of collaborative conversation is making learning a disposition to the situated-ness of the world.

Fam and colleague in Chap. 7 of this book take this challenge head on and describe their efforts to build transdisciplinary forms of higher education and illustrates that community engagement and endorsement are critical. Maguire in Chap. 8 of this book also makes a modest claim for the success of her work on transdisciplinary doctorates, pointing to the notion of mattering—that which is worthy, important. It is a theme that is either implicit or explicit in many of the chapters in this volume. This deeply moral and political contextualization requires the attributes of a *phronimos* (an agent of practical wisdom) in judgement and action. It requires speaking out about what matters.

In this sense, I am reminded of Foucault's Paris lectures (2010) on *parrhesia*—of speaking to the truth—and of Peters' (2003) discussion of truth-telling as educational practice. To speak out when the consequences may be unfavourable to oneself requires courage and a reconstitution of what higher education has become, a return to an ethos of personal growth that better represents what humanity might become, rather than offering the other—a service of blinkered higher-skill training. Moreover, it requires the teacher to be trustworthy and veracious. It requires a form of self-trust that can avoid the deception of societies and of oneself, a deception prevalent even before, the advent a post-trust era, but more acute and acceptable within it. Such speaking out is offered to us in Chap. 14 of this book where De Santolo reminds us to be humble in our predominantly Western thought in the book with a balancing discussion of the importance of recognizing other indigenous knowledge and meaning making.

19.6 Concluding Comments

Aristotle offers argument; deductive, inductive and abductive reasoning; and examples (cases) to facilitate action for the good of the *polis*, the community. In the *Rhetoric,* he was keen to point out that those who practised these skills were people whose interest was that of *polis*, not their own, and that they had the courage to speak to it. The authors in this volume show the same passion, concern and responsibility to influence others in a way that they believe is for the benefit of all of us. The contributors who have developed the educative *gnoseology* and moral importance of transdisciplinary and collaborative understanding of the realities of our world need to speak out about them. There is real benefit to society in confronting the powers that reduce knowledge creators and holders of different forms to lesser contributors, and that change the grammar of knowledge and personal dignity. And there is value in evaluating methods of problem solving that do not have individual satisfaction as their end.

I believe that the contributions in this volume offer the insights into how this might be achieved and have made significant progress in achieving it, yet much still needs to be done if the dignity and integrity of the world and its humanity are to be worthy of mattering. The development of the realities in which knowledge emerges do not warrant notions of certainty but if we develop imaginative ways, we can open up our understanding of realties laminated and currently hidden to us and in doing so realize knowledges that help us to behave better. It is the uncovering and the unconcealing of what is present in a multi-modal investigation of knowledge forms that transdisciplinary forces allow to emerge. Detailed discussion of transdisciplinary knowledge is however for another book and not the purpose of the collection of essays offered here and whatever our philosophical stance, this seems a good reason to write another book and celebrate the contributions made in this one!

References

Bernstein, B. (1996). *Pedagogy, symbolic control and identity theory*. London: Taylor & Francis.

Bruffee, K. A. (1999). *Collaborative learning: Higher education, interdependence and the authority of knowledge*. Baltimore: Johns Hopkins University Press.

Dehart, S. M. (1995). The convergence of *praxis* and *theoria* in Aristotle. *Journal of the History of Philosophy, 33*(1), 7–27.

Dunne, J. (1993). *Back to rough ground – 'Phronesis' and 'techne' in modern philosophy and in Aristotle*. Notre Dame: University of Notre Dame Press.

Eikeland, O. (2007). From epistemology to gnoseology – Understanding the knowledge claims of action research. *Management Research News, 30*(5), 344–358.

Eikeland, O. (2008). *The ways of Aristotle: Aristotelian phronesis, Aristotelian philosophy of dialogue, and action research*. Bern: Peter Lang.

Flyvbjerg, B. (2001). *Making social science matter – Why social inquiry fails and how it can succeed again*. Cambridge: Cambridge University Press.

Foucault, N. (2010). *The government of self and others*. Basingstoke: Palgrave Macmillan.

Gadamer, H. G. (1975). *Truth and Method*. New York: Seabury.

Johnson, M. R. (2015). Aristotle's architectonic sciences. In D. Ebrey (Ed.), *Theory and practice in Aristotle's natural philosophy* (pp. 163–186). Cambridge: Cambridge University Press.

Oakeshott, M. (1975/2003). *On human conduct*. Oxford: Oxford University Press.

Papastephanou, M. (2010). Aristotle, the action researcher. *Journal of Philosophy of Education, 44*(4), 589–597.

Papastephanou, M. (2013). Aristotelian gnoseology and work-based learning. In P. Gibbs (Ed.), *Learning, work and practice: New understanding* (pp. 107–120). Dordrecht: Springer.

Peters, M. (2003). Truth-telling as an educational practice of the self: Foucault, *parreshia* and the ethics of subjectivity. *Oxford Review of Education, 29*, 207–223.

Pickup, A. (2016). Critical inquiry as virtuous truth-telling: Implications of Phronesis and Parrhesia. *Critical Questions in Education (Special Issue), 7*(3), 177–196.

Polkinghorne, D. E. (2004). *Practice and the human sciences – The case for a judgment-based practice of care*. Albany: State University of New York Press.

Surprenant, C. W. (2012). Politics and practical wisdom: Rethinking Aristotle's account of *phronesis*. *Topoi, 31*, 221–227.